# SITE-WIDE GROUNDWATER CORRECTIVE MEASURES STUDY REPORT

# SUBMISSION 1 (SECTIONS 1-4)

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# 1.0 INTRODUCTION

The Tradepoint Atlantic (TPA) Property (the Site) encompasses approximately 3,100 acres located on a peninsula situated on the Patapsco River near its confluence with the Chesapeake Bay. Numerous groundwater investigations have been conducted of various areas of the overall TPA Property. This Site-wide Groundwater Corrective Measures Study (CMS) Report addresses groundwater impacts identified on the Site, ~~other than in the areas designated as Coke Point Area (CPA,), Parcel B18, which includes:~~excluding the following areas:

- the Coke Point Landfill and the Coke Oven Area including Parcels B10, B11, B12, and B18;
- ~~and~~ the Rod and Wire Mill Area (RWM); and
- ~~excludes~~ any historical offshore impacts.

The CPA and RWM and any transport of constituents of concern in groundwater to offshore areas to the extent it is currently occurring from these two areas will be addressed under separate CMS Reports.

This Site-Wide Groundwater CMS Report Submission 1 (Sections 1-4) is an interim submission including the first four sections of the CMS Report, and covering:

- Identification of groundwater constituents of potential concern (COPCs),
- Development of COPC cleanup levels for groundwater, and
- Comparison of site-wide groundwater results to the COPC cleanup levels for groundwater.

In accordance with the previously provided schedule, subsequent submissions will include:

- 2nd Submission:
  - Development of COPC cleanup levels for soil to groundwater,
  - Figures showing exceedances of the COPC cleanup levels for soil to groundwater (potential continuing source areas).
- 3rd Submission:
  - Screening of Potential Technologies
  - Proposed Alternatives for Evaluation
- Full Report submission:
  - Detailed Evaluation of Alternatives,
  - Comparative Analysis and Preferred Alternative.

## 1.1 Overall Purpose of the Corrective Measures Study

This CMS addresses groundwater impacts and sources of releases to groundwater, which may include Non-Aqueous Phase Liquid (NAPL) or impacted soil, throughout the TPA Property outside of the RWM and CPA areas and offshore areas. Potential direct exposures to soil will be addressed through separate Phase II investigations and Response and Development Work Plans (RADWPs). Assessment and remediation of historical offshore impacts from a variety of potential sources pre-dated TPA's use and ownership of the TPA Property and are being ~~undertaken~~ addressed separately by the USEPA and are not within the scope of TPA's responsibility.

## 1.2 Approach for Corrective Measures Study

At issue are COPCs in the shallow and intermediate zone groundwater within the TPA Property, as defined herein. The approach to addressing groundwater is to:

- identify sources that need to be controlled to prevent cross-media transfer to groundwater (e.g., soil to groundwater),
- develop and evaluate alternatives to control any continuing releases of contaminants of concern (COCs) to groundwater from identified source areas, and
- develop and evaluate alternatives to reduce levels of COCs in groundwater and reduce potential migration of contaminated groundwater to or across the shoreline/property boundary to the extent practicable.

~~Historical offshore impacts from a variety of potential sources pre-dated TPA's use and ownership of the TPA Property and are being addressed separately by the USEPA. This CMS also evaluates exposure control measures (e.g., institutional and engineering controls). These measures are evaluated relative to their ability to control exposure in the short-term, while other measures work toward the reduction of contaminant levels and extent over time.~~

# 2.0 DESCRIPTION OF CURRENT CONDITIONS

## 2.1 SITE SETTING AND USE

The TPA Property is located in Baltimore County, Maryland within the southeastern corner of the Baltimore metropolitan area, and approximately nine miles from downtown Baltimore, Maryland. The property encompasses approximately 3,100 acres of land located on a peninsula situated on the Patapsco River near its confluence with the Chesapeake Bay, and physically positioned in the mouth of the heavily industrialized and urbanized Baltimore Harbor / Patapsco River region. **Figure 1** shows the location and boundaries of the TPA Property. **Figure 2** shows the shaded area addressed in the Site-wide Groundwater CMS, and the relationship to the CPA and RWM areas which will~~to~~ be addressed in separate groundwater CMS reports.

From the late 1800s until 2012, the property was used for the production and manufacturing of steel. Iron and steel production operations and processes at the TPA Property included raw material handling, coke production, sinter production, iron production, steel production, and semi-finished and finished product preparation. In 1970, Sparrows Point was the largest steel facility in the United States, producing hot and cold rolled sheets, coated materials, pipes, plates, and rod and wire. The steelmaking operations at the facility ceased in fall 2012, and the steel mill has been demolished. Current plans for the TPA Property include redevelopment over the next several years. Some portions of the TPA Property have already undergone remediation and/or redevelopment.

### 2.1.1 Land Use and Surface Features

The TPA Property is predominantly zoned Industrial, and the Site use is expected to be limited to non-residential uses in the future. There are two yacht clubs located on the Site along the Jones Creek and a proposed county recreational area to be located on the Site adjacent to and contiguous to the yacht clubs along the Jones Creek. Light industrial and commercial properties are located northeast of the TPA Property and to the northwest across Bear Creek. Residential areas of Edgemere and Fort Howard are located northeast of the property across Jones Creek and to the southeast across Old Road Bay, respectively. Residential and commercial areas of Dundalk are located northwest of the property across Bear Creek.

### 2.1.2 Regional Geology

The TPA Property is located within the Atlantic Coastal Plain Physiographic Province (Coastal Plain). The western boundary of the Coastal Plain is the "Fall Line", which separates the Coastal Plain from the Piedmont Plateau Province. The Fall Line runs from northeast to southwest along the western boundary of the Chesapeake Bay, passing through Elkton (MD), Havre de Grace

(MD), Baltimore City (MD), and Laurel (MD). The eastern boundary of the Coastal Plain is the off-shore Continental Shelf.

The unconsolidated sediments beneath the TPA Property belong to the Talbot Formation (Pleistocene), which is then underlain by the Cretaceous formations which comprise the Potomac Group (Patapsco Formation, Arundel Formation and the Patuxent Formation). The Potomac Group formations are comprised of unconsolidated sediments of varying thicknesses and types, which may be several hundred feet to several thousand feet thick. These unconsolidated formations may overlie deeper Mesozoic and/or Precambrian bedrock. Depth to bedrock is approximately 700 feet within the TPA Property.

### 2.1.3 Site Geology / Hydrogeology

Land reclamation and fill placement occurred at the facility for decades beginning in the early 1900s and continuing until the 1980s. The fill deposits consist primarily of iron- and steel-making slag. Slag is a byproduct of iron and steel making that has been used as onsite fill material since operations began at Sparrows Point facility. In general, stream channels and estuaries that originally extended into the Sparrows Point peninsula were filled; the southern shoreline of the peninsula was expanded southward into the Patapsco River with fill; and fill was used to create level grades. Refer to **Figure 3** for a comparison of the 1916 Shoreline vs. the current TPA Property extents and boundary. The fill deposits are thickest (up to 40 feet) in the historic stream channels and estuaries, particularly Humphrey Creek, Greys Creek, Jones Creek, and Old Road ~~Bay and in the two landfill areas, including Greys Landfill and Coke Point Landfill, where total fill thickness may be up to 70 feet~~. Refer to **Figure 4** for a depiction of the estimated thickness of the saturated slag across the TPA Property, based on boring logs. Because of the extensive presence of slag fill across the TPA Property, these manmade fill deposits are called the Slag-Fill Unit.

Three near surface hydrogeologic, or groundwater, zones were identified from previous site investigations. According to the *Site Wide Investigation Report of Nature & Extent of Releases to Groundwater from the Special Study Areas* (SSAs) (URS 2005, revised 2007), these zones were designated shallow, intermediate, and lower. The hydrogeologic boundary elevations vary by several feet across the TPA Property.

The shallow water table below the TPA Property occurs within recent sedimentary deposits or slag fill material (Slag-Fill Unit) and includes the unconfined water table at the TPA Property. Monitoring wells designated as shallow are screened within this shallow, unconfined unit. The "shallow" bottom-of-screen elevations generally range from +5 to -20 feet above mean sea level (amsl). In some areas of the TPA Property, the slag fill is directly underlain by, and connected to, the coarser grained beds or lenses within the Talbot Formation that comprise the Upper Talbot Channel Unit. In these areas, the slag fill and Upper Talbot Channel Units form a single groundwater flow system. In much of the investigation area, the slag fill material is underlain by finer-grained silts and clays that comprise the Talbot Clay Aquitard. In these areas, shallow groundwater flow may be separated from groundwater in any underlying coarse-grained beds or lenses.

The intermediate hydrogeologic zone includes the unconfined to partially confined groundwater in the Pleistocene Upper Talbot unit. The "intermediate" bottom-of-screen elevations generally range from -20 to -50 feet amsl. The presence of clay and silt layers within the intermediate hydrogeologic zone likely retard the vertical recharge of groundwater from the upper fill material.

The lower hydrogeologic zone includes the confined groundwater in the Lower Talbot or Upper Patapsco Sand unit. The "lower" bottom-of-screen elevations generally range from -50 to -141 feet amsl. The lower hydrogeologic zone was not a primary focus in this groundwater investigation. Hydrogeologic zones at greater depth are known to exist based on a review of the regional geology; however, these deeper units are isolated from the upper three units and impacts have not been identified from former iron and steel operations.

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##### *2.1.3.1 Groundwater Potentiometric Surface*

On the northern portion of the TPA Property, site-wide shallow groundwater is characterized by the relatively higher groundwater elevations (i.e., mounds) located at Greys Landfill (Parcel A12, groundwater elevation of 13.07 ft amsl) and in the southeastern corner of Parcel A11 (groundwater elevation of 12.96 ft amsl). Groundwater appears to flow radially from these mounds, north and west towards Bear Creek / Patapsco River, south towards Tin Mill Canal, and east towards the retention pond on Parcel A15. On the southern portion of the TPA Property, site-wide shallow groundwater is characterized by several groundwater mounds along Sparrow Point Road (generally consistent with the topography, with groundwater elevations up to 13.07 ft amsl). From Sparrow Point Road, shallow groundwater then flows north and northwest towards Tin Mill Canal, east towards Jones Creek and Old Road Bay, and south towards the Patapsco River. In addition, there is a slight mound in the shallow groundwater near Parcels B4 and B18 (groundwater elevation of 10.54 ft amsl), with shallow groundwater flowing radially from this area. In general, site-wide shallow groundwater flows towards Tim Mill Canal and towards the surrounding water bodies. Refer to **Figure 5**.

On the northern portion of the TPA Property, site-wide intermediate groundwater is characterized by a slight mound located at the south-central portion of Parcel A11 (groundwater elevation of 5.97 ft amsl) and another slight mound located in the northern portion of Parcel B14 (groundwater elevation of 3.99 ft amsl). Groundwater appears to flow radially from each mound. On the southern portion of the TPA Property, the intermediate groundwater elevation is relatively flat; the highest groundwater elevation is 1.70 ft amsl at the CPA. However, there is a steep groundwater gradient associated with the pumping in the Graving Dock Area, although the impact is limited to the immediate vicinity only. Refer to **Figure 6**.

As part of the *Site-Wide Groundwater Study Report* (ARM, 2017), average hydraulic gradients were calculated for several discharge areas. The calculated hydraulic gradients ranged from 0.001131 to 0.018090.

As part of the *Groundwater Study Report* (CH2MHill, 2001), a tidal study was conducted. The study concluded that the inland extent of tidal influence ranged from approximately 135 ft (eastern portion of Parcel B10 along the Turning Basin) to 340 ft (western portion of Parcel B10 along the Patapsco River. An average inland extent of tidal influence of 285 ft was projected.

#### *2.1.3.2 Groundwater Quality in the Slag Fill Unit*

As discussed in Section 2.1.3, the shallow groundwater aquifer lies within the slag fill unit. As part of the *Site-Wide Groundwater Study* (ARM, 2017), an evaluation was conducted of site wide groundwater quality. The Study included an evaluation of boring logs and well construction logs constructed in the slag fill unit, in order to determine and map the thickness of slag fill within the saturated zone. The conclusion presented was that most of the locations where groundwater is present in slag fill are located beyond the historical 1916 shoreline (**Figure 3**).

In addition, historic and current groundwater quality data was reviewed, particularly with respect to pH, total dissolved solids (TDS), and chloride. Groundwater associated with slag fill can exhibit extremely basic pH concentrations (pH greater than 10) rendering it unusable for almost any purpose without treatment. pH values obtained from sampling events from each well or piezometer were contoured to create maps (shallow and intermediate) showing pH contours and delineating areas of the TPA Property where the pH exceeds 10 (**Figures 7 and 8**). As expected, the pH values in the shallow zone are indicative of the groundwater being present in slag fill within a large portion of the TPA Property. The general pH concentration in the intermediate zone is within the acceptable range for groundwater use (between 4 and 10).

Saltwater intrusion has been an issue at the TPA Property due to historical pumping for industrial water use. As part of the *Groundwater Study Report* (CH2MHill, 2001), TDS and chloride concentrations for shallow and deep zone wells across the TPA Property were collected. In addition, specific conductance data were collected during the sampling of each well across the TPA Property as part of the Phase II investigations. In the *Site-Wide Groundwater Study* (ARM, 2017), the SC data was converted to equivalent TDS values (1000 uS/cm = 534 mg/L TDS). In addition, the transmissivity of the shallow and intermediate aquifer was calculated based on the conductivity values and the aquifer thicknesses, respectively. Refer to **Figures 9 and 10** for TDS concentrations in the shallow and intermediate groundwater aquifers. Refer to **Figures 11 and 12** for transmissivity rates in the shallow and intermediate groundwater aquifers.

As part of the *Site-Wide Groundwater Study* (ARM, 2017), the pH, TDS, and transmissivity data for the shallow zone was overlaid, presenting areas that exhibit no potential for future groundwater use. Locations with elevated TDS (above 1,500 mg/L), low transmissivity (below 1,000 gallons/day/foot), or elevated pH (above 10) in the shallow groundwater are considered to not contain usable groundwater and are shown in **Figure 13**.

Iron and manganese (Fe/Mn) are common in shallow and intermediate groundwater at Sparrows Point. For the groundwater samples included in this Site-Wide CMS, manganese was detected in 85% of groundwater samples and iron was detected in 80% of groundwater samples. USEPA has not set maximum contaminant levels (MCLs) for iron and manganese; however, there are Project Action Levels (PALs) established as screening levels for the Facility (refer to **Appendix A**). Secondary maximum contaminant levels (SMCLs) recommended in the National Secondary Drinking Water Regulations are not health-based, but rather are set for aesthetic reasons and are not enforceable by USEPA, but are intended as guides to the States. The SMCL for iron is 0.3 mg/L (site-specific PAL is 14 mg/L) and the SMCL for manganese is 0.05 mg/L (site-specific PAL is 0.43 mg/L). High levels of these contaminants can result in discolored water, stained plumbing fixtures, and an unpleasant metallic taste to the water.

As per USEPA's *Role of Background in the CERCLA Cleanup Program*, USEPA defines "background" as constituents or locations that are not influenced by the releases from a site, and then further breaks background conditions into naturally occurring and anthropogenic. Anthropogenic is defined as natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question) (USEPA, 2002). For the purposes of this Site-Wide CMS, the slag fill is considered an anthropogenic background condition unrelated to releases from RCRA regulated units or SWMUs. While slag related COPCs (iron and manganese) will be evaluated as COPCs, impacts related to slag COPCs and non-slag COPCs will be differentiated in the discussion of the nature and extent of identified groundwater impacts.

~~Other former steel work facilities have also recognized slag used as a fill material is a contributor to metals in groundwater. For example, the *Site Assessment Report, Mingo Junction Steel Works, Corrective Action Areas VIM and VIIM* (CEC, 2021) noted that slag contains elevated concentrations of iron and manganese. The Report also indicated that it was likely that the concentrations of cobalt, iron, manganese, thallium, and vanadium detected in groundwater at the Mingo Junction Steel Works Site were related to leaching from the slag fill.~~

### 2.1.4 Groundwater Use

The Patapsco aquifer was used as a source of groundwater prior to 1900 and during the early part of the 20th century. Because the Patapsco aquifer widely subcrops beneath the brackish Patapsco River, elevated chloride concentrations became a major problem in areas near the Patapsco River estuary. By 1945, almost all water production from the Patapsco had ended due to excessive chloride near the Harbor, Canton, and Dundalk areas. The Sparrows Point plant was the only major user of the Patapsco aquifer in 1945. Water production totaled about 3 million gallons per day; however, by the later 1940's and 1950's, many of the Sparrows Point wells were affected by elevated levels of chlorides and were abandoned. As of 1985, there were no major use of the Patapsco aquifer in the immediate vicinity of the Patapsco River estuary.

There is no current ongoing usage of groundwater beneath the Facility, but there is groundwater extraction for structural maintenance purposes (minimize buoyancy forces on the structure) at the graving dock, located along the western shore and north of the CPA, as described below. Groundwater is monitored for various purposes on a regular frequency to assess remediation efforts at the former Rod and Wire Mill Area and Coke Oven Area; regular groundwater monitoring also occurs at Greys Landfill. Across the entire Sparrows Point facility there are hundreds of monitoring wells constructed into the shallow aquifer and a lesser number into the intermediate aquifer. There are few monitoring wells constructed into the deeper aquifer. There are no monitoring wells into the Arundel Formation and none into the Patuxent below the Arundel.

The Sparrows Point Shipyard (Shipyard, refer to **Figure 2**) contains a "graving dock," used for the repair or scrapping of ships under dry conditions. Ships enter the graving dock when it is filled with water, via the Patapsco River, and then a gate is closed, and water is removed. A central feature of the graving dock is the underdrain pumping system. The underdrain pumping system collects groundwater and pumps the water to the Patapsco River. The Shipyard's pumping system causes groundwater from the northern regions of the CPA to flow towards the extraction point at the graving dock. The water from the underdrain pumps is discharged to the Patapsco River following treatment pursuant to a National Pollutant Discharge Elimination System (NPDES) discharge permit issued by the Maryland Department of the Environment (MDE).

## 2.2 Summary of Previous Investigations

Initial Phase I and Phase II Investigations were conducted in 1980 and 1981. Since that time, there have been multiple investigations for soil, groundwater, soil vapor, surface water, sediment, and pore water at the TPA Property. Some of the main reports summarizing the extensive sampling history include:

- *Description of Current Conditions* (Rust Environment and Infrastructure, January 1998)
- *Groundwater Study Report* (CH2M Hill, December 2001)
- *Site Wide Investigation, Report of Nature and Extent of Releases to Groundwater from the Special Study Areas (URS, 2005)*
- *Area B Groundwater Phase II Investigation Report* (ARM, 2016a)
- *Finishing Mills Groundwater Phase II Investigation Report* (ARM, 2016b)
- *Site-Wide Groundwater Study Report* (ARM, 2017)

In addition, the nature and extent of groundwater impacts has been delineated in dedicated groundwater investigations conducted as part of the Phase II studies of the numerous investigation parcels and supplemental NAPL and groundwater impact delineation studies conducted on a number of the parcels. Also, semi-annual groundwater monitoring is conducted around the Greys Landfill in Parcel A12 and periodic NAPL gauging has been conducted in areas where measurable NAPL has been identified. These reports have been submitted to the agencies for review and approval.

## 2.3 Source Areas

As discussed in Section 2.1, the TPA Property was operational from the late 1800s until 2012 for iron and steel production. The steelmaking operations at the facility ceased in fall 2012, and the steel mill has been demolished. All historic sources (buildings, tanks, etc.) of the COCs have been removed. The principal potential factor affecting groundwater quality is residual NAPL identified in piezometers and monitoring wells in several locations, which is discussed in detail in **Section 4.0**.

The slag fill contributes iron and manganese to the shallow groundwater; in addition, groundwater associated with slag fill can exhibit extremely high (alkaline) pH concentrations (refer to **Section 2.1.3.2**).

# 3.0 CORRECTIVE ACTION OBJECTIVES

USEPA prepared a groundwater use determination memorandum dated April 13, 2018 (**Appendix A**) in which it indicated that the USEPA expects corrective actions / final remedies to return usable groundwater to its maximum beneficial use, where practicable, within a reasonable timeframe. For groundwater in the shallow and intermediate aquifers at Sparrows Point, the USEPA determined that drinking water use can be excluded from consideration when developing groundwater cleanup levels based on excess TDS, both low and high pH, the occurrence of the groundwater in non-natural slag fill which contributes iron and manganese, and saltwater intrusion resulting in elevated chloride. The memorandum indicated that maximum beneficial use of shallow and intermediate groundwater at Sparrows Point is industrial, commercial or dewatering and that groundwater cleanup levels should be developed based on State surface water quality criteria. The memorandum also indicated that more stringent groundwater cleanup levels may be appropriate in specific areas of the Sparrows Point Site, based on potential exposures or pathways not associated with groundwater use (e.g., vapor intrusion or direct contact during excavation).

## 3.1 Corrective Action Objectives

The Corrective Action Objectives (CAOs) for the site-wide groundwater are defined as follows:

1) control any releases of COPCs to the groundwater to the extent practicable,
2) control human exposure to the COPCs remaining in the groundwater,
3) ensure that groundwater containing elevated concentrations of COPCs will not adversely impact ecological receptors or adjacent surface water and pore water quality, and
4) achieve cleanup levels for groundwater based on its maximum beneficial use, to the extent practicable.

## 3.2 Constituents of Potential Concern

The entire groundwater data set was screened against drinking water criteria (MCLs or Regional Screening Levels [RSLs]) to identify COPCs (refer to **Appendix B**). COPC screening was completed assuming a Target Risk (TR) of $10^{-6}$ and Target Hazard Quotient (THQ) of 0.1. The initial screening also identified parameters detected at a frequency greater than 5%. Based on that data set, parameters were identified as COPCs if:

- The compound was detected in groundwater at a frequency of more than 5%;
- The maximum detection exceeded the MCL for drinking water;
- If no applicable MCL, the maximum detection exceeds the USEPA Region 3 RSL for tap water.

In addition, iron and manganese were excluded as COPCs as they are associated with the slag fill. If the maximum detection exceeds the RSL but not the MCL, then the parameter was not identified as a COPC. For metals, both total and dissolved concentrations were included in the COPC screening.

Based on this analysis, a total of 49 parameters were identified as COPCs. This includes 14 volatile organic compounds (VOCs), 17 semivolatile organic compounds (SVOCs), 15 inorganic parameters, and polychlorinated biphenyl (PCBs) (total).

| VOCs | SVOCs | Metals | Other |
|---|---|---|---|
| 1,1-Dichloroethane | 1,1-Biphenyl | Aluminum | PCBs (total) |
| 1,1-Dichloroethene | 2-Methylnaphthalene | Arsenic | |
| 1,2,4-Trimethylbenzene | 2-Methylphenol | Beryllium | |
| 1,3,5-Trimethylbenzene | 2,4-Dimethylphenol | Cadmium | |
| 1,4-Dioxane | Benz[a]anthracene | Chromium | |
| 2-Butanone (MEK) | Benzo[a]pyrene | Chromium VI | |
| Benzene | Benzo[b]fluoranthene | Cobalt | |
| cis-1,2-Dichloroethene | Benzo[k]fluoranthene | Cyanide (available) | |
| Methyl tert-butyl ether (MTBE) | Chrysene | Lead | |
| Pyridine | Fluoranthene | Nickel | |
| Tetrachloroethene | Fluorene | Selenium | |
| Toluene | Indeno[1,2,3-c,d]pyrene | Silver | |
| Trichloroethene | Naphthalene | Thallium | |
| Vinyl chloride | Pentachlorophenol | Vanadium | |
| | Phenol | Zinc | |
| | Pyrene | | |
| | Pyridine | | |

For cyanide, initial groundwater sampling in several areas (including the Area B Groundwater Investigation area and the Finishing Mills Groundwater Investigation area) indicated elevated levels of total cyanide in shallow groundwater samples. However, cleanup levels (including the MCL, the Vapor Intrusion Screening Level (VISL), and ambient water quality criteria) are based on free or available cyanide. Therefore, a supplemental cyanide investigation was conducted (ARM, 2017), with samples collected from 13 locations for available cyanide. Based on the results, a very small fraction of the total cyanide in groundwater is present in the form of available cyanide. Sample results for free or available cyanide only (not total cyanide) will be used for comparison with calculated preliminary groundwater cleanup levels.

## 3.3 POTENTIAL RECEPTORS & PATHWAYS

### 3.3.1 Human Health

The TPA Property is predominantly zoned Industrial, and the Site use is expected to be limited to non-residential uses in the future. There are two yacht clubs located on the Site along the Jones Creek and a proposed county recreational area to be located on the Site adjacent to and contiguous to the yacht clubs along the Jones Creek. Therefore, no residential receptor scenarios need to be considered. Currently, groundwater is extracted only for construction purposes, remedial purposes, or dewatering of the Graving Dock. There are no other groundwater uses onsite, and there is currently no direct exposure to groundwater for human receptors, except during subsurface construction activities for site redevelopment. The current and reasonably anticipated on-site human health receptor scenarios considered are therefore:

- On- Site Industrial Workers: may have a potential to be exposed to vapors through vapor intrusion to indoor air; and
- On- Site Utility Workers: may have a potential for short-term exposure to shallow groundwater during intrusive work.

For off-site human health receptor scenarios, the only risk is COPCs potentially entering surface water / sediments via groundwater- to- surface water transport. Potential exposure of boaters (including kayakers or canoers) bypassing the TPA Property would be brief, and therefore is considered inconsequential. However, the Jones Creek portion of the TPA Property (eastern boundary, including several marinas, yacht clubs, and potentially the location of a future recreational park) could be used by recreational waders, potentially resulting in exposure to COPCs in surface water via incidental ingestion and dermal contact and to COPCs in sediment via dermal contact.

In EPA's *Phase I Offshore Investigation Report* (EA, 2016), the conceptual site model assumed two populations as potential receptors: recreational users and commercial waterman. The northwest portion of the Site is included within the Northeast / Near Shore (NNS), or Phase I, grouping. The offshore areas near Sparrows Point are not considered a high use area for swimming or other water activities. However, access is not controlled to the waters surrounding the Site, and swimming and other activities around Sparrows Point are assumed to occur only on a limited basis. The exposure routes for both recreational users (adult, adolescent, and child) and commercial waterman were identified as: 1) dermal contact with surface water; 2) dermal contact with sediment; and 3) ingestion of fish and crabs. No COPCs were determined for potential receptor direct contact with surface water and sediment in the NNS area. As a result, the evaluation of ingestion of fish and crab tissue play a distinctive role in the conclusions of the Human Health Risk Assessment. Exposure Point Concentrations (EPCs) for metals, PAHs, and PCBs in aquatic organism tissue were derived from the field-collected fish and crabs collected from adjacent areas in association with the Coke Point Risk Assessment. The evaluation of the field-collected tissue did not indicate any non-cancer hazards above 1 (there are no non-cancer concerns for the NNS Area), and carcinogenic results for all receptors were within USEPA's acceptable excess cancer risk range of $10^{-6}$ to $10^{-4}$ and within MDE's acceptable excess cancer risk range of $10^{-6}$ to $10^{-5}$. The results of the Human Health Risk Assessment indicate that there are no human health concerns based on potential for exposure to Site-related COPCs in the NNS area compared to both EPA and MDE's acceptable excess cancer risk range for all receptor scenarios (EA, 2016). In addition, as the field-collected fish and crabs were collected related to the Coke Point Risk Assessment (and Coke Point is one of the more impacted areas within Sparrows Point), this evaluation is applicable to the Site as a whole. Therefore, there is unlikely to be any unacceptable human health risk related to ingestion of fish and crabs for the Site. However, to be conservative, it will be evaluated.

However, due to the recreational activities in the Jones Creek portion of the site, the following off-site human health receptor scenario is included:

- Off- Site Recreational Waders: may have a potential for short term exposure to surface water and sediment.
- Off-Site Recreational User: may have a potential for exposure due to fish / crab ingestion.

### 3.3.2 Ecological Receptors

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Two offshore investigations focused on sediment, pore water, and stormwater samples were conducted for the USEPA to assess the conditions of the offshore environment and to support delineation of offshore impacts. The USEPA studies were reviewed to evaluate whether current groundwater discharges with the area of this site-wide groundwater CMS contain COPCs at concentrations that may contribute to any identified offshore issues.

### *3.3.2.1 Pore Water*

The *Phase I Offshore Investigation* (EA, 2016) focused on the Bear Creek, or the northwest shoreline. Pore water samples were collected from selected surface sediment grab sampling locations near the shoreline, to assess potential inputs to Bear Creek via groundwater upwelling. Pore water samples collected along the RWM Shoreline will be assessed in the RWM CMS Report. Outside the RWM area, along the shoreline north of the 695 Bridge, there were no exceedances in pore water samples of the ecological surface water screening values. South of the RWM area, there was one pore water sample (PW-F05) with an exceedance of the ecological surface water screening values for total cyanide. However, as discussed in Section 3.2, the supplemental cyanide investigation (ARM, 2017) concluded that a very small fraction of the total cyanide in groundwater is present in the form of available cyanide. Based on this analysis, groundwater discharges were not adversely impacting pore water quality in 2015 along the northwest shoreline. However, pore water sampling results were not available across the entire site.

### *3.3.2.2 Sediment*

Multiple rounds of sediment sampling have been conducted along both the northwest and southeast shorelines of the Site. The *Phase I Offshore Investigation* (EA, 2016) included sediment sampling along the northwest shoreline (Bear Creek and the Patapsco River). Surface sediment grab samples were collected from the NNS area and analyzed for metals and cyanide (18 samples), PAHs (17 samples) and VOCs, SVOCs, and PCBs (9 samples). Based on the ecological risk assessment, total chromium and zinc from sediment in the NNS grouping were identified as COPCs to aquatic and benthic organisms.

The *Southeast Area Sediment Assessment, Second Round of Sample Collection* (Weston, 2018) focused on Old Road Bay and Jones Creek, or southeast shoreline. This field work included sediment sampling only (no pore water), with collection of 34 surface sediment samples and 10 subsurface sediment samples, with samples analyzed for SVOCs, PCBs, and metals. The report calculated average concentrations of analytes (for two areas: Old Road Bay / Jones Creek, and the Patapsco River) and compared those to the NOAA SQuiRT Probable Effect Concentration (PEC) screening benchmarks. For compounds with no listed PEC values, Biological Technical Assistance Group (BTAG) values were used as screening benchmarks. Based on Weston's analysis, averaged concentrations exceeded the PEC or BTAG for the following:

- Old Road Bay / Jones Creek: six metals (chromium, iron, lead, manganese, silver, and zinc), and five PAHs (acenaphthene, acenaphthylene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene)
- Patapsco River: two metals (iron and manganese), six PAHs (2-methylnaphthalene, acenaphthlene, acenaphthylene, benzo(b)fluoranthene, benzo(g,h,i)perylene, and indeno(1,2,3-c,d)pyrene)

Of the above, PEC values exist only for chromium, lead, and zinc. All other exceedances were based on BTAG screening benchmarks which are more conservative.

The *Final Trip Report* (Weston, 2020) was prepared for EPA and also included sediment sampling from around the entire perimeter of the site in October 2019. A total of 35 sediment samples were collected, with an additional 10 sediment samples collected to characterize sediment conditions outside the potential impacts from the Site. All sediment sample results were compared to EPA Region 3 BTAG freshwater screening criteria, and to the 'background' sediment sample results. Sediment sampling results along the northwest and southeast shorelines were within three times of the background locations, and were not identified as COPCs. The highest concentrations were detected offsite of the CPA and the TMC, which will be included under a separate CMS Report.

These previous rounds of sediment sampling identified the following COPCs in sediment:

- Northwest Shoreline: chromium and zinc
- Southeast Shoreline: six metals (chromium, iron, lead, manganese, silver, and zinc), and seven PAHs (2-methylnaphthalene, acenaphthene, acenaphthylene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene)

ARM reviewed groundwater results for the above listed compounds, in order to determine whether Sparrows Point groundwater discharges could potentially contribute to the identified impacts in sediments in the northwest and southeast portions of the Site (refer to **Tables 1A and 1B**, respectively). The analyte was excluded from consideration if it was not identified as a COPC (refer to Section 3.2).

Based on that review, only two compounds remained for the Northwest portion of the site: total chromium and zinc. nine compounds remained for the Southeastern portion of the site: chromium, iron, ~~hexavalent chromium,~~ lead, manganese, silver, zinc, 2-methylnaphthalene, benzo(b)fluoranthene, ~~dibenzo(a,h)anthracene,~~ and indeno(1,2,3-c,d)pyrene. ARM then calculated the geometric mean for each sediment COPC based on shoreline groundwater sampling results from the Northwest and Southeast shorelines (refer to **Appendix F** for figures showing the groundwater sampling locations and the groundwater datasets utilized). For non-detect results, one half of the detection limit was used for calculation purposes. For the Northwest shoreline (**Table 1A**) and the Southeast Shoreline (**Table 1B**), ~~compared~~ the geometric mean for ~~concentration~~ COPCs in monitoring wells along ~~the entire site-wide~~each section of shoreline was compared to the surface water aquatic life salt water chronic screening level (refer to Section 3.4.2) without any Mixing Factor.

For the Northwest Shoreline (**Table 1A**), the geometric mean for both chromium and zinc were below the surface water aquatic life salt water chronic screening level. Therefore, chromium and zinc were eliminated as sediment COPCs along the Northwest Shoreline.

For the Southeast Shoreline (**Table 1B**), ~~T~~the geometric mean of ~~eight~~ seven of the nine compounds (chromium, lead, manganese, zinc, 2-methylnaphthalene, benzo(b)fluoranthene, ~~dibenzo(a,h)anthracene,~~ and indeno(1,2,3-c,d)pyrene) were below these criteria and were, therefore, eliminated as sediment COPCs along the Southwest Shoreline. For the one remaining compound (silver), the geometric mean concentration (~~2.70~~3.0 µg/L) exceeded the aquatic life screening level (0.23 µg/L) ~~(although note, the geometric mean concentration is well below the MCL of 9.0 µg/L)~~. However, all silver results were non-detect (out of 32 samples)~~based on the low detection frequency (silver was detected in 4 of 105 samples at approximately 3.8% detection frequency)~~, with an ~~the~~ elevated detection limit (6 µg/L) compared to the surface water aquatic life salt water chronic screening level (0.23 µg/L). ~~, and~~ Based on the lack of detections and the lack of known source areas with silver as a COC, silver concentrations in groundwater are not anticipated to have any adverse impact on sediment in the surrounding Southeast offshore environment. For iron, the geometric mean was above the surface water aquatic life salt water chronic screening level. However, iron is related to the slag fill and considered anthropogenic background unrelated to releases from RCRA regulated units or SWMUs.

~~The geometric mean concentrations in monitoring wells along the site-wide shoreline were below the applicable screening levels for protection of aquatic life.~~ This analysis indicates that perimeter groundwater associated with non-slag related COPCs does not present the potential to contribute to any of the sediment quality issues identified along the northwest shoreline in 2015 (EA, 2016), the southeast shoreline in 2017 (Weston, 2018) or the entire shoreline in 2019 (Weston, 2020).

#### *3.3.2.3 Surface Water*

No surface water samples were collected during the *Phase I Offshore Investigation* (EA, 2016) or the *Southeast Area Sediment Assessment, Second Round of Sample Collection* (Weston, 2018). While extensive surface water sampling was conducted offshore from the RWM and CPA, there is limited surface water data around the remainder of the site perimeter.

#### *3.3.2.4 Summary*

Based on the review of the USEPA offshore studies (EA, 2016 and Weston, 2018), groundwater discharges were not adversely impacting the observed pore water quality in 2015 along the northwest shoreline or sediment quality in 2015 along the northwest shoreline or in 2017 along the southeast shoreline. For this Site-Wide CMS (covering areas outside of the RWM and CPA), there is no reason to believe that conditions have changed significantly since those offshore studies were completed (i.e. all steel production and manufacturing operations ceased in 2012 and all identified source areas have been removed). The USEPA offshore studies did not include surface water sampling.

Based on the results, groundwater associated with non-slag related COPCs does not appear to be currently contributing to any of the sediment quality issues identified along the shoreline ~~there is no risk to ecological receptors from sediment quality~~ at the Site. However, pore water results and surface water results are not available site wide. Therefore, groundwater cleanup levels for ecological receptor protection will be developed to ensure protection of both surface water and pore water and will be based on surface water criteria. Specifically, the cleanup levels will ensure that any discharge of groundwater that may contain COPCs to surface water or pore water will not result in surface water concentrations (after mixing and attenuation) or pore water concentrations (after attenuation) that may present unacceptable risks to ecological receptors inhabiting the surface water and pore water surrounding the Site.

### 3.3.3 Resource Restoration

USEPA expects final remedies to return usable groundwater to its maximum beneficial use, where practicable, within a timeframe that is reasonable. As previously discussed, USEPA has concluded that the maximum beneficial use of groundwater at Sparrows Point is industrial, commercial, or dewatering and that groundwater cleanup levels should be developed based on State surface water quality criteria. Therefore, Resource Restoration groundwater cleanup levels will be based on:

- ~~an~~ Industrial Non-Potable Water User ~~(Composite Worker)~~; may have a potential to be exposed through dermal contact and vapor inhalation, and ~~on~~
- ~~p~~Protection of ecological receptors from any discharge of groundwater that may contain COPCs.

The Industrial Non-Potable Water User is intended to be a worst-case scenario receptor and assumes groundwater exposure during truck washing or similar, and discharge of that groundwater to the surrounding water bodies.

## 3.4 Media Cleanup Levels and Point(s) of Compliance

Target Media Cleanup Levels and points of compliance were developed during the CMS. In order to address the proposed CAOs for all COPCs, target media cleanup levels have been developed to protect both human health (**Section 3.4.1**), the environment (**Section 3.4.2**), and groundwater as a resource (**Section 3.4.3**). Risk Based Screening Levels (RBSLs) were developed for each COPC/receptor/pathway using USEPA toxicity criteria and standard default exposure parameter values for the Utility Worker scenarios and for the physical characteristics and incidental water intake rate for the Recreational Wader.

### 3.4.1 Human Health – Non-Residential

As discussed in Section 3.3.1, the current and reasonably anticipated future receptor scenarios considered are therefore:

- On- Site Industrial Workers: may have a potential to be exposed to vapors through vapor intrusion to indoor air;
- On- Site Utility Workers: may have a potential for short-term exposure (via dermal contact and vapor inhalation) to shallow groundwater during intrusive work; ~~and~~
- Off- Site Recreational Waders: may have a potential for short term exposure to surface water and sediment via incidental ingestion and dermal contact; and~~.~~
- Off-Site Recreational User: may have a potential risk due to fish and crab ingestion.

Therefore, with respect to potential human exposure, groundwater cleanup levels will be derived for each of the COPCs for the above receptors / exposure pathways.

*3.4*

*3.4.1*

#### *3.4.1.1 On-Site Industrial Workers*

Onsite industrial workers may have a potential to be exposed to groundwater COPCs through vapor intrusion to indoor air. USEPA's commercial scenario sub-slab vapor VISLs were selected as the appropriate preliminary groundwater cleanup level for this scenario, and are presented in **Table 2**. The point of compliance would be Site-wide.

#### *3.4.1.2 On-Site Utility Workers*

On-site Utility Workers may have a potential for short-term exposure to shallow groundwater during intrusive work (excavations or trenches) in areas of the TPA Property where groundwater is within 15 feet of the ground surface. These receptors could come into direct contact with groundwater in excavations and trenches, and could also be exposed to COPC vapors arising from groundwater both at and below the trench base for short periods of time.

The COPC list identified in Section 3.2 includes multiple cancer and non-cancer COPCs. In order to account for cumulative risks, a target cancer risk of 1E-06 was utilized in the below equations to ensure that cumulative carcinogenic risk for groundwater remains below acceptable risk levels. For non-cancer COPCs, they were separated by target organ. The target non-cancer HQ (1.0) was divided by the number of COPCs contributing to that target organ HQ, in order to obtain a target HQ per target organ per COPC. This target HQ (per target organ per COPC) was used in the below equations to calculate preliminary groundwater cleanup levels for on-site utility workers to ensure that cumulative non-cancer risk by target organ remain below acceptable risk levels. Refer to Appendix D for preliminary groundwater cleanup level calculations.

Dermal Contact

For inorganic COPCs, the Utility Worker dermal contact RBSL ($RBSL_{inorg\_derm\_uw}$) for dermal contact with groundwater in the trench is calculated based on the EPA RSL equations for resident / dermal contact with groundwater / tapwater. These equations have been conservatively used to calculate the Utility Worker dermal contact RBSL as follows:

$$RBSL_{inorg\_derm\_uw}\left[\frac{\mu g}{L}\right] = \frac{DA_{event\_uw} x\ 1{,}000\ cm^3/L}{K_p\ x\ ET_{uw}}$$

For organic COPCs for which exposure time ($ET_{uw}$) is less than or equal to the chemical- specific time to reach steady state ($t^*$), the Utility Worker dermal contact RBSL ($RBSL_{org\_derm\_uw}$) is calculated as:

$$RBSL_{org\_derm\_uw}\left[\frac{\mu g}{L}\right] = \frac{DA_{event_{uw}} x\ 1{,}000\,\frac{cm^3}{L}}{2\ x\ FA\ x\ K_p\ x\ \sqrt{\frac{6\ x\ \tau_{event} x\ ET_{uw}}{\pi}}}$$

For organic COPCs for which exposure time ($ET_{rec}$) is greater than the chemical- specific time to reach steady state ($t^*_{rec}$), the Utility Worker dermal contact RBSL ($RBSL_{org\_derm\_uw}$) is calculated as:

$$RBSL_{org\_derm\_uw}\left[\frac{\mu g}{L}\right] = \frac{DA_{event\_uw}\ x\ 1{,}000\,\frac{cm^3}{L}}{FA\ x\ K_p\ x\ \left[\frac{ET_{uw}}{1+B} + 2\ x\ \tau_{event_{uw}}\ x\ \left[\frac{1+3B+3B^2}{(1+B)^2}\right]\right]}$$

Where:

$DA_{event\_uw}$ = Absorbed dose per event for Utility Workers ($\mu g/cm^2$-event). Calculated.

$K_p$ = Dermal permeability coefficient of COPC in water (cm/hour). Chemical specific, refer to **Table 4**.

$\tau_{event}$ = lag time per event (hour/event). Chemical specific, refer to **Table 4**.

$t^*$ = time to reach steady state (hours). Chemical specific, refer to **Table 4**.

FA = fraction absorbed from water (unitless). Chemical specific, refer to **Table 4**.

$ET_{uw}$ = exposure time (hours/event), 8 hours/event. Refer to **Table 3**.

B = ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless). Chemical specific, refer to **Table 4**.

The absorbed dose per event ($DA_{event\_uw(c)}$) for carcinogenic effects for all COPCs is calculated as:

$$DA_{event\_uw(c)}\left[\frac{\mu g}{cm^2 - event}\right] = \frac{TR\ x\ AT_c\ x\ LT\ x\ BW_{uw}\ x\ GIABS\ x\ 1000\ \mu g/mg}{ED_{uw}\ x\ EF_{uw}\ x\ SA_{uw}\ x\ SF_o}$$

and $DA_{event\_uw(nc)}$ for non- carcinogenic effects of all COPC types is calculated as:

$$DA_{event\_uw(nc)}\left[\frac{\mu g}{cm^2 - event}\right] = \frac{THQ\ x\ AT_{nc}\ x\ ED_{uw}\ x\ BW_{uw}\ x\ RfD\ x\ GIABS\ x\ 1000\ \mu g/mg}{ED_{uw}\ x\ EF_{uw}\ x\ SA_{uw}}$$

Where:

TR = Target Risk (unitless), TR = 1E-6. Refer to **Table 3**.
THQ = Target Hazard Quotient (unitless) per COPC per target organ. Refer to **Appendix D**.
$AT_c$ = averaging time for carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
$AT_{nc}$ = averaging time for non- carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
LT = lifetime (yrs), 70 yrs. Refer to **Table 3**.
$BW_{uw}$ = body weight (kg), 80 kg. Refer to **Table 3**.
$SA_{uw}$ = exposed body surface area ($cm^2$), 3,527 $cm^2$. Refer to **Table 3**.
$EF_{uw}$ = exposure frequency (events/year), 250 events/yr. Refer to **Table 3**.
$ED_{uw}$ = exposure duration (years), 1 yr. Refer to **Table 3**.
GIABS = gastrointestinal absorption fraction (unitless). Chemical specific, refer to **Table 4**.
$SF_o$ = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$. Chemical specific, refer to **Table 4**.
RfD = reference dose (mg/kg-day). Chemical specific, refer to **Table 4**.

Vapor Inhalation

Before calculating vapor inhalation risks to the Utility Worker, each COPC must first meet the criteria for volatility where the Henry's Law Constant must be greater than $1 \times 10^{-5}$ atm-$m^3$/mol. If it does not, then the chemical is not volatile enough to be assessed for vapor inhalation risks.

For carcinogenic effects, the Utility Worker direct contact inhalation RBSLs ($RBSL_{dir\_inhal\_uw(c)}$) are calculated in accordance with the VDEQ equations for a construction/utility worker in a trench:

$$RBSL_{dir\_inhal\_uw(c)}\left[\frac{\mu g}{L}\right] = \frac{TR\ x\ AT_c}{EF_{uw}\ x\ ED_{uw}\ x\ ET_{uw} x\ \frac{1\ day}{24\ hours} x\ IUR\ x\ VF_{\leq 15_{uw}}}$$

For non-carcinogenic effects, the Utility Worker direct contact inhalation RBSLs ($RBSL_{dir\_inhal\_uw(nc)}$) are calculated as:

$$RBSL_{dir\_inhal\_uw(nc)}\left[\frac{\mu g}{L}\right] = \frac{THQ\ x\ AT_{nc}\ x\ RfC\ x\ 1{,}000\ \mu g/mg}{EF_{uw}\ x\ ED_{uw}\ x\ ET_{uw} x\ \frac{1\ day}{24\ hours} x\ VF_{\leq 15_{uw}}}$$

Where:
TR = Target Risk (unitless), TR = 1E-6. Refer to **Table 3**.
THQ = Target Hazard Quotient (unitless) per COPC per target organ. Refer to **Appendix D**.
$AT_c$ = averaging time for carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
$AT_{nc}$ = averaging time for non- carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
$EF_{cuw}$ = exposure frequency (days/year), 250 days/yr. Refer to **Table 3**.
$ED_{cuw}$ = exposure duration (years), 1 yr. Refer to **Table 3**.
$ET_{cuw}$ = exposure time (hours/day), 8 hrs/day. Refer to **Table 3**.
IUR = inhalation unit risk $(\mu g/m^3)^{-1}$. Chemical specific, refer to **Table 4**.
RfC = reference concentration ($mg/m^3$). Chemical specific, refer to **Table 4**.
$VF_{\leq 15}$ = volatilization factor where depth to groundwater is ≤ 15 ft bgs ($L/m^3$). Chemical specific, refer to **Table 4**.

For groundwater within 15 feet of the ground surface, volatilization factors (VF) and overall mass transfer coefficients (K) are calculated in accordance with the VDEQ equations for a construction/utility worker in a trench.

$$VF_{<15\_uw}\left[\frac{L}{m^3}\right] = \frac{K\ x\ A\ x\ F\ x\ 10^{-3}\frac{L}{cm^3} x\ 10^4\frac{cm^2}{m^2}\ x\ 3600\ sec/hr}{[ACH_{uw}]\ x\ V}$$

Where

$$K = \frac{1}{\frac{1}{k_{iL}} + \frac{R\ x\ T}{H_i\ x\ k_{iG}}}$$

$$k_L = \left(\frac{MW_{O_2}}{MW_i}\right)^{0.5}\ x\ \frac{T}{298}\ x\ k_L, O_2$$

$$k_G = \left(\frac{MW_{H_2O}}{MW_i}\right)^{0.335}\ x\ \left(\frac{T}{298}\right)^{1.005}\ x\ k_G, H_2O$$

Where:
K = overall mass transfer coefficient (cm/sec). Chemical specific, refer to **Table 4**.
$ki_L$ = liquid-phase mass transfer coefficient (cm/sec). Chemical specific, refer to **Table 4**.
R = ideal gas constant (atm-m$^3$/mole-°K). Assumption of 8.2 x $10^{-5}$.
T = groundwater temperature (°K). Assumption of 11°C or 284°K, refer to **Table 3**.
$H_i$ = Henry's Law constant of component i (atm-m$^3$/mole). Chemical specific, refer to **Table 4**.
$k_{iG}$ = gas-phase mass transfer coefficient (cm/sec). Chemical specific, refer to **Table 4**.
$MW_i$ = molecular weight of component i (g/mol). Chemical specific, refer to **Table 4**.
A = Area of Trench (m$^2$). Assumption of 2.44 m$^2$, refer to **Table 3**.
F = fraction of floor through which contaminant can enter (unitless). Assumption of 1, refer to **Table 3**.
$ACH_{uw}$ = air changes per hour (utility trench) (h$^{-1}$). Assumption of 2 per hour, refer to **Table 3**.
V = volume of trench (m$^3$). Assumption of 5.95 m$^3$, refer to **Table 3**.
$MW_{O2}$ = molecular weight of $O_2$. 32 g/mol.
$k_L$, $O_2$ = liquid- phase mass transfer coefficient of oxygen at 25°C. 0.002 cm/sec, refer to **Table 3**.
$MW_{H2O}$ = molecular weight of water. 18 g/mol.
$k_G$,$H_2O$ = gas- phase mass transfer coefficient of water at 25°C. 0.833 cm/sec, refer to **Table 3**.

<u>Combined Exposure Routes</u>

For volatile COPCs, combined dermal and inhalation RBSLs are calculated. For carcinogenic effects, the Utility Worker direct contact inhalation RBSLs ($RBSL_{comb\_uw(c)}$) are calculated as:

$$RBSL_{comb\_uw(c)}\left[\frac{\mu g}{L}\right] = \frac{1}{\frac{1}{RBSL_{org\_derm(c)}} + \frac{1}{RBSL_{dir\_inhal\_uw(c)}}}$$

For non- carcinogenic effects, the Utility Worker direct contact inhalation RBSLs ($RBSL_{comb\_uw(nc)}$) are calculated as:

$$RBSL_{comb\_uw(nc)}\left[\frac{\mu g}{L}\right] = \frac{1}{\frac{1}{RBSL_{org\_derm(c)}} + \frac{1}{RBSL_{dir\_inhal\_uw(nc)}}}$$

The lowest of the carcinogenic and non-carcinogenic combined direct contact screening levels was selected as the RBSLs for the Utility Worker scenario, and are presented in **Table 2**. The point of compliance for these cleanup levels would be Site-wide.

### *3.4.1.3 Off-Site Recreational Waders*

As discussed in Section 3.3.1, the Jones Creek portion of the TPA Property (eastern boundary) could be used by recreational waders, potentially resulting in exposure to COPCs in surface water and sediment via incidental ingestion and dermal contact. Both adolescent and adult scenarios were considered.

Sediment Contribution

Recreational waders are potentially exposed to COPCs in sediment via dermal contact. The recreational wader scenario is most likely to occur in Jones Creek~~;~~, therefore, the sediment dataset utilized is based on sediment samples collected from off the eastern shoreline of the Site only. ~~To address this risk,~~ EPCs were calculated for all COPCs based on the sediment sampling results from ~~*Phase I Offshore Investigation* (EA, 2016), the~~ the *Sparrows Point Southeast Area Sediment Assessment, Final Trip Report* (Weston, 2017), the *Southeast Area Sediment Assessment, Second Round of Sample Collection* (Weston, 2018), and the *Final Trip Report* (Weston, 2020). ~~For the *Phase I Offshore Investigation* (EA, 2016), all sediment results from the Northeast/Near Shore Sampling were utilized. For the Final Trip Report, all sediment samples (excluding those offshore from the RWM and CPA) were utilized.~~ Refer to Appendix E for a figure showing the sediment sample locations and the sediment dataset. EPCs were calculated as follows:

- Metals/VOCs/SVOCs/PCBs:
  - For COPCs with more than 10 detections, 95% Upper Confidence Limits (UCLs) were calculated. For non-detect concentrations, one half of the detection limit was utilized.
  - If there were limited detections (less than ten), then the maximum concentration was used.
- ~~VOCs/SVOCs (limited detections rendering UCL analysis impractical):~~
  - If all results were non-detect, then no EPC was calculated.
  - ~~If there were limited detections, then the maximum concentration was used.~~

Refer to Appendix E for the sediment data set utilized to calculate the UCLs and EPCs and the UCL output. Based on an adolescent and an adult recreational wader scenario and the calculated EPCs, the cancer Target Risk and non-cancer Target Hazard Quotient were calculated. The total TR for ~~an adolescent~~ a recreational wader from dermal contact with sediment was ~~9.37~~6.51E-08 for an adolescent and 1.41E-07 for an adult, indicating no risk. For the non-cancer HQ, COPCs were separated by target organ, and a total HQ was calculated for each target organ. This represents the risk contribution from sediment.

In order to calculate surface water screening levels, the sediment contribution non-cancer HQ was subtracted from the target HQ (1.0). The remaining HQ was then divided by the number of COPCs contributing to that target organ HQ, in order to obtain a target HQ per target organ per COPC. This target HQ (per target organ per COPC) was used in the following equations to calculate surface water screening levels for incidental ingestion and dermal contact.

For cancer TR, a target risk of 1E-06 was utilized, in order to ensure that cumulative carcinogenic risk for groundwater remains below acceptable risk levels. Refer to Appendix D for preliminary groundwater cleanup level calculations.

Incidental Ingestion (Surface Water)

For carcinogenic effects, the Recreational Wader oral (surface water) RBSL ($RBSL_{rec\_oral\_sw(c)}$) is based on the EPA RSL equations for recreator for incidental ingestion of surface water, and is calculated as:

$$RBSL_{rec\_oral\_sw(c)}\left[\frac{\mu g}{L}\right] = \frac{TR\ x\ AT_c\ x\ LT\ x\ BW_{rw} x\ 1{,}000\ \mu g/mg}{SF_o\ x\ EF_{rec}\ x\ ED_{rec}\ x\ ET_{rec} x\ IR_{w\_rec}}$$

For non- carcinogenic effects, the Recreational Wader oral RBSL ($RBSL_{rec\_oral\_sw(nc)}$) is calculated as:

$$RBSL_{rec\_oral\_sw(nc)}\left[\frac{\mu g}{L}\right] = \frac{THQ\ x\ BW_{rec}\ x\ AT_{nc}\ x\ ED_{rec}\ x\ RfD_o\ x\ 1{,}000\ \mu g/mg}{EF_{rec}\ x\ ED_{rec}\ x\ ET_{rec} x\ IR_{w\_rec}}$$

Where:
TR = Target Risk (unitless), TR = 1E-6. Refer to **Table 3**.
THQ = Target Hazard Quotient (unitless) per COPC per target organ. Refer to **Appendix D**.
$AT_c$ = averaging time for carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
$AT_{nc}$ = averaging time for non- carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
LT = lifetime (yrs), 70 yrs. Refer to **Table 3**.
$BW_{rec}$ = body weight (kg), 80 kg for adult, 56.8 kg for adolescent. Refer to **Table 3**.
$EF_{rec}$ = exposure frequency (days/year), 32 days/yr. Refer to **Table 3**.
$ED_{rec}$ = exposure duration (years), 20 yrs for adult, 6 yrs for adolescent. Refer to **Table 3**.
$ET_{rec}$ = exposure time (hours/day), 2 hrs/day. Refer to **Table 3**.
$IR_{w\_rec}$ = incidental surface water ingestion rate (L/hr), 0.11 L/hr. ~~Chemical specific, refer~~Refer to **Table ~~3~~4**.
~~$CAF_o$ = oral carcinogenic adjustment factor (unitless). Chemical specific, refer to Table 4.~~
$SF_o$ = oral cancer slope factor ($(mg/kg\text{-}day)^{-1}$). Chemical specific, refer to **Table 4.**
RfD = reference dose (mg/kg-day). Chemical specific, refer to **Table 4**.

Dermal Contact (Surface Water)

For inorganic COPCs, the Recreational Wader dermal contact (surface water) RBSL ($RBSL_{inorg\_derm\_sw\_rec}$) is based on the EPA RSL equations for resident / dermal contact with groundwater / tapwater, and is calculated as:

$$RBSL_{inorg\_derm\_sw\_rec}\left[\frac{\mu g}{L}\right] = \frac{DA_{event\_rec\_sw} x\ 1{,}000\ cm^3/L}{K_p\ x\ ET_{rec}}$$

For organic COPCs for which exposure time ($ET_{rec}$) is less than or equal to the chemical- specific time to reach steady state ($t^*_{rec}$), the Recreational Wader dermal contact RBSL ($RBSL_{rec\_derm\_sw}$) is calculated as:

$$RBSL_{rec\_derm\_sw}\left[\frac{\mu g}{L}\right] = \frac{DA_{event\_rec\_sw}\ x\ 1{,}000\frac{cm^3}{L}}{2\ x\ FA\ x\ K_p\ x\ \sqrt{\frac{6\ x\ \tau_{event\_rec}\ x\ ET_{rec}}{\pi}}}$$

For organic COPCs for which exposure time ($ET_{rec}$) is greater than the chemical- specific time to reach steady state ($t^*_{rec}$), the Recreational Wader dermal contact RBSL ($RBSL_{rec\_derm\_sw}$) is calculated as:

$$RBSL_{rec\_derm\_sw}\left[\frac{\mu g}{L}\right] = \frac{DA_{event\_rec\_sw}\ x\ 1{,}000\frac{cm^3}{L}}{FA\ x\ K_p\ x\ \left[\frac{ET_{rec}}{1+B} + 2\ x\ \tau_{event\_rec}\ x\ \left[\frac{1+3B+\ 3B^2}{(1+B)^2}\right]\right]}$$

The absorbed dose per event ($DA_{event\_rec\_sw(c)}$) for carcinogenic effects for all COPCs is calculated as:

$$DA_{event\_rec\_sw(c)}\left[\frac{\mu g}{cm^2 - event}\right] = \frac{TR\ x\ AT_c\ x\ LT\ x\ BW_{rec}\ x\ GIABS\ x\ 1000\ \mu g/mg}{ED_{rec}\ x\ EF_{rec}\ x\ SA_{rec}\ x\ SF_o}$$

and $DA_{event\_rec\_sw(nc)}$ for non- carcinogenic effects of all COPC types is calculated as:

$$DA_{event\_rec\_sw(nc)}\left[\frac{\mu g}{cm^2 - event}\right] = \frac{THQ\ x\ AT_{nc}\ x\ ED_{rec}\ x\ BW_{rec}\ x\ RfD\ x\ GIABS\ x\ 1000\ \mu g/mg}{ED_{rec}\ x\ EF_{rec}\ x\ SA_{rec}}$$

Where:
$DA_{event\_rec\_sw}$ = Absorbed dose per event for Recreational Waders ($\mu g/cm^2$-event). Calculated.



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$K_p$ = Dermal permeability coefficient of COPC in water (cm/hour). Chemical specific, refer to **Table 4**.
FA = fraction absorbed from water (unitless). Chemical specific, refer to **Table 4**.
$t^*$ = time to reach steady state (hours). Chemical specific, refer to **Table 4**.
$\tau_{event}$ = lag time per event (hours/event). Chemical specific, refer to **Table 4**.
B = ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless). Chemical specific, refer to **Table 4**.
TR = Target Risk (unitless), TR = 1E-6. Refer to **Table 3**.
THQ = Target Hazard Quotient (unitless) per COPC per target organ. Refer to **Appendix D**.
$AT_c$ = averaging time for carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
$AT_{nc}$ = averaging time for non- carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
LT = lifetime (yrs), 70 yrs. Refer to **Table 3**.
$BW_{rec}$ = body weight (kg), 80 kg for adult, 56.8 kg for adolescent. Refer to **Table 3**.
$SA_{rec}$ = exposed body surface area for surface water exposure ($cm^2$), 20,670 $cm^2$ for adult and 15,170 $cm^2$ for adolescent. Refer to **Table 3**.
$EF_{rec}$ = exposure frequency (events/year), 32 events/yr. Refer to **Table 3**.
$ED_{rec}$ = exposure duration (years), 20 yrs for adult, 6 yrs for adolescent. Refer to **Table 3**.
$ET_{rec}$ = exposure time (hours/event), 2 hrs/event. Refer to **Table 3**.
GIABS = gastrointestinal absorption fraction (unitless). Chemical specific, refer to **Table 4**.
$SF_o$ = oral cancer slope factor ($(mg/kg\text{-}day)^{-1}$). Chemical specific, refer to **Table 4**.
RfD = reference dose (mg/kg-day). Chemical specific, refer to **Table 4**.

Combined Exposure Routes

For carcinogenic effects, the combined oral/dermal and surface water/sediment RBSLs ($RBSL_{rec\_comb(c)}$) for the Recreational Wader is calculated as:

$$RBSL_{rec\_comb(c)}\left[\frac{\mu g}{L}\right] = \frac{1}{\frac{1}{RBSL_{rec\_oral(c)}} + \frac{1}{RBSL_{drec\_derm(c)}}}$$

For non- carcinogenic effects, the combined oral and dermal RBSLs ($RBSL_{rec\_comb(nc)}$) for the Recreational Wader is calculated as:

$$RBSL_{rec\_comb(nc)}\left[\frac{\mu g}{L}\right] = \frac{1}{\frac{1}{RBSL_{rec\_oral(nc)}} + \frac{1}{RBSL_{drec\_derm(nc)}}}$$

Please note, the above values represent surface water RBSLs ($RBSL_{SW}$). In order to obtain groundwater RBSLs ($RBSL_{gw}$) that would be protective of the Recreational Wader scenario, a mixing factor (MF) has been applied:

$$RBSL_{GW} = RBSL_{SW} \; x \; Mixing \; Factor$$

Groundwater that may contain COPCs and that flows into surface water along the shoreline will mix with the surface water in the water body. For small tidal inlets and bays, tidal exchange is the most significant component of surface water mixing, such as the case of Old Road Bay with the larger Patapsco River. It is understood that there is significant dilution between the groundwater and surface water interface, particularly when dealing with a tidally influenced river. For example, one study found that under tidal pumping, high velocities coupled with hydrodynamic dispersion resulted in considerable mixing of groundwater and river water, creating a 1-m deep mixing interval within the hyporheic zone. Conservative solutes in groundwater discharging to the river were diluted significantly, on the order of 99.9% and 84% during flooding and ebbing tide conditions, respectively (Bianchin, 2010). For ~~small tidal inlets or bays,~~water bodies such as Old Road Bay, tidal exchange with the larger Patapsco River is the most significant component of surface water mixing. In addition to the tidal exchange, there also may be other freshwater inputs such as stream discharges or treated effluent discharges that will mix with the groundwater discharge.

Groundwater and surface water data collected from several areas of the CPA have been evaluated to derive an empirical groundwater to surface water mixing / attenuation factor: Cell 2 (located along the southern portion of the inlet associated with the Graving Dock, also has a seawall), Cell 3 (located along the northern portion of a cove along the western shore of the CPA), and Cell 5 (located along the western portion of the Turning Basin). For each cell and the overall CPA, geometric means were calculated for surface water samples and for shoreline monitoring well locations based on benzene and naphthalene concentrations (refer to **Appendix C**). Based on the calculated geometric means, groundwater to surface water mixing / attenuation factors were calculated (refer to **Appendix C**). A conservative surface water mixing / attenuation factor of **121**, which was the factor from Cell 3 for benzene, was selected for use in this Site Wide CMS. This factor was selected for several reasons: 1) the Cell 3 cove is small and would have less mixing than other areas surrounding the entire Sparrows Point peninsula; 2) Cell 3 included 31 surface water samples, which was more than for the other Cells and is a robust data set; 3) the Cell 3 factor was the lowest factor calculated based on the CPA data, and therefore will be conservative for use Site-Wide.

The surface water mixing / attenuation factor of **121** will be used site-wide, and applied to the surface water screening levels for the Recreational Wader to obtain preliminary groundwater cleanup levels for the protection of the Recreational Wader based on exposure to sediment and surface water.

The lowest of the carcinogenic and non-carcinogenic combined oral and dermal screening levels was selected as the RBSLs for the Recreational Wader scenario, and are presented in **Table 2**. The point of compliance would be groundwater at the shoreline/property boundary.

#### *3.4.1.4 Off-Site Recreational User*

As discussed in Section 3.3.1, the HHRA completed in the *Phase I Offshore Investigation Report* (EA, 2016), indicated that there are no human health concerns based on potential for exposure to Site-related COPCs via ingestion of fish and crabs in the NNS area compared to both EPA and MDE's acceptable excess cancer risk range for all receptor scenarios (EA, 2016). In addition, as the field-collected fish and crabs were collected related to the Coke Point Risk Assessment (and Coke Point is one of the more impacted areas within Sparrows Point), this evaluation is applicable to the Site as a whole. However, to be conservative, potential risk to an off-site recreational user via fish and crab ingestion has been evaluated.

The COPC list identified in Section 3.2 includes multiple cancer and non-cancer COPCs. In order to account for cumulative risks, a target cancer risk of 1E-06 was utilized in the below equations to ensure that cumulative carcinogenic risk for groundwater remains below acceptable risk levels. For non-cancer COPCs, they were separated by target organ. The target non-cancer HQ (1.0) was divided by the number of COPCs contributing to that target organ HQ, in order to obtain a target HQ per target organ per COPC. This target HQ (per target organ per COPC) was used in the below equations to calculate preliminary groundwater cleanup levels for off-site recreational users to ensure that cumulative non-cancer risk by target organ remain below acceptable risk levels. Refer to Appendix D for preliminary groundwater cleanup level calculations.

As a starting point, the Code of Maryland Regulations, 26.08.02.03-2 Numerical Criteria for Toxic Substances in Surface Waters, Human Health for Consumption of Organism Only (updated February 24, 2021) was utilized. In order to develop preliminary groundwater cleanup levels to be protective of off-site recreational users via fish and crab ingestion, the groundwater to surface water mixing / attenuation factor of **121** (as discussed in Section 3.4.1.3) was applied to the applicable surface water levels for Human Health for Consumption of Organism Only.

For COPCs where there was no MDE screening level for Human Health for Consumption of Organism Only, the EPA RSL equations for fish ingestion were utilized to obtain a screening level for the concentration in the fish tissue that can be consumed.

For carcinogenic effects, the Fish Ingestion RBSL ($RBSL_{rec\_fish(c)}$) is calculated as:

$$RBSL_{rec\_fish(c)}\left[\frac{mg}{kg}\right] = \frac{TR\ x\ AT_c\ x\ LT\ x\ BW_{rec\_fish}}{EF_{rec\_fish}\ x\ ED_{rec\_fish}\ x\ SF_o\ x\ IRF\ x\ \frac{10^{-6}kg}{1\ mg}}$$

For non- carcinogenic effects, the Fish Ingestion RBSL ($RBSL_{rec\_fish(nc)}$) is calculated as:

$$RBSL_{rec\_fish(nc)}\left[\frac{mg}{kg}\right] = \frac{THQ\ x\ BW_{rec\_fish}\ x\ AT_{nc}\ x\ ED_{rec\_fish}\ x\ RfD_o}{EF_{rec\_fish}\ x\ ED_{rec\_fish}\ x\ IRF\ x\ \frac{10^{-6}kg}{1\ mg}}$$

Where:
TR = Target Risk (unitless), TR = 1E-6. Refer to **Table 3**.
THQ = Target Hazard Quotient (unitless) per COPC per target organ. Refer to **Appendix D**.
$AT_c$ = averaging time for carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
$AT_{nc}$ = averaging time for non- carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
LT = lifetime (yrs), 70 yrs. Refer to **Table 3**.
$BW_{rec\_fish}$ = body weight (kg), 80 kg. Refer to **Table 3**.
$EF_{rec\_fish}$ = exposure frequency (days/year), 32 days/yr. Refer to **Table 3**.
$ED_{rec\_fish}$ = exposure duration (years), 26 yrs. Refer to **Table 3**.
IRF = fish ingestion rate (mg/day), 230,000 mg/day. Refer to **Table 3**.
$SF_o$ = oral cancer slope factor ($(mg/kg\text{-}day)^{-1}$). Chemical specific, refer to **Table 4.**
RfD = reference dose (mg/kg-day). Chemical specific, refer to **Table 4**.

~~The lowest of the carcinogenic and non-carcinogenic screening levels was selected as the screening level for the concentration in the fish tissue that can be consumed.~~ The corresponding surface water screening level was calculated based on the screening level in the fish and the fish bioconcentration factor.

$$RBSL_{rec\_fish}\left[\frac{\mu g}{L}\right] = \frac{RBSL_{rec\_fish}\left[\frac{mg}{kg}\right]\ x\ \frac{1000\ \mu g}{1\ mg}}{BCF\left[\frac{L}{kg}\right]}$$

Where:
BCF = Fish bioconcentration factor (L/kg). Chemical specific, refer to **Table 4**.

The lowest of the carcinogenic and non-carcinogenic screening levels was selected as the screening level for the concentration in the crab and fish tissue that can be consumed. In order to develop preliminary groundwater cleanup levels to be protective of off-site recreational users via fish and crab ingestion, the groundwater to surface water mixing / attenuation factor of **121** (as discussed in Section 3.4.1.3) was applied to the calculated surface water levels for fish ingestion. These were utilized only when no MDE screening level for Human Health for Consumption of Organism Only was available.

The preliminary groundwater cleanup levels for all COPCs are presented in **Table 2 and Table 5**. The point of compliance would be groundwater at the shoreline/property boundary.

### 3.4.2 Ecological Receptors

As discussed in **Section 3.3.2**, current groundwater discharges are not adversely impacting the observed sediment quality along the shoreline. However, the USEPA offshore studies did not include surface water sampling, and only included limited pore water sampling. Therefore, groundwater cleanup levels for ecological receptor protection will be developed to ensure protection of both surface water and pore water. Specifically, the cleanup levels will ensure that any discharge of groundwater that may contain COPCs to surface water or pore water, will not result in surface water concentrations (after mixing and attenuation) or pore water concentrations (after attenuation) that may present unacceptable risks to ecological receptors inhabiting the surface water or pore water surrounding the Site. Groundwater cleanup levels were derived with a point of compliance at the shoreline/property boundary.

In order to obtain appropriate preliminary groundwater cleanup levels, various sources were identified for the selection of surface water screening levels. Below is a hierarchy of the screening levels utilized. Surface water screening levels for marine or saltwater aquatic life, and for chronic exposure, were selected. If no marine or saltwater screening level was available, then fresh water screening levels were utilized as a conservative option.

1. USEPA NRWQCs (USEPA 2014a) for ecological risk (Saltwater Aquatic Life Continuous Criterion Concentration).
~~2.~~~~1.~~ ~~USEPA, Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-ionic Organic Contaminants. Table 3-1 for Conventional and narcosis chronic toxicity values for marine water (October 2017).~~
~~3.~~2. Code of Maryland Regulations, 26.08.02.03-2 Numerical Criteria for Toxic Substances in Surface Waters, Salt Water – Chronic (updated February 24, 2021).
~~4.~~3. NOAA Screening Quick Reference Tables (SQuiRTs), Marine Surface Water – Chronic (2008).
~~5.~~4. USEPA Region III ~~Biological Technical Assistance Group (~~BTAG~~)~~ Marine Screening Benchmarks (July 2006).
~~6.~~5. NOAA SQuiRTs, Fresh Surface Water – Chronic (2008).
6. USEPA Region III BTAG Freshwater Screening Benchmarks (July 2006).

USEPA, Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-ionic Organic Contaminants. Table 3-1 for Conventional and narcosis chronic toxicity values for marine water (October 2017).

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The hierarchy utilized for the pore water screening levels (as per EPA Guidance, surface water screening levels are also utilized for pore water screening) differed slightly:

1. USEPA NRWQCs (USEPA 2014a) for ecological risk (Saltwater Aquatic Life Continuous Criterion Concentration).
2. USEPA, Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-ionic Organic Contaminants. Table 3-1 for Conventional and narcosis chronic toxicity values for marine water (October 2017).
3. ~~2.~~ Code of Maryland Regulations, 26.08.02.03-2 Numerical Criteria for Toxic Substances in Surface Waters, Salt Water – Chronic (updated February 24, 2021).
4. ~~3.~~ NOAA SQuiRTs, Marine Surface Water – Chronic (2008).
5. ~~4.~~ USEPA Region III BTAG Marine Screening Benchmarks (July 2006).
6. ~~5.~~ NOAA SQuiRTs, Fresh Surface Water – Chronic (2008).
7. ~~6.~~ USEPA Region III BTAG Freshwater Screening Benchmarks (July 2006).

~~7.1. USEPA, Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-ionic Organic Contaminants. Table 3-1 for Conventional and narcosis chronic toxicity values for marine water (October 2017).~~

If no ecological screening level was identified based on the above hierarchy, then the Risk Assessment Information System was utilized to review other available ecological screening levels. The selected screening levels represent surface water concentrations (or pore water concentrations) that would be protective of ecological receptors. To determine applicable target cleanup levels for groundwater and in the absence of site-specific empirical data, mixing and/or attenuation factors have been considered. It is understood that there is significant dilution between the groundwater and surface water interface, particularly when dealing with a tidally influenced river. For example, one study found that under tidal pumping, high velocities coupled with hydrodynamic dispersion resulted in considerable mixing of groundwater and river water, creating a 1-m deep mixing interval within the hyporheic zone. Conservative solutes in groundwater discharging to the river were diluted significantly, on the order of 99.9% and 84% during flooding and ebbing tide conditions, respectively (Bianchin, 2010).

*3.4.1*

*3.4.2*

#### *3.4.2.1 Surface Water*

To determine groundwater cleanup levels that are protective of ecological receptors with respect to surface water, a surface water mixing factor of **121** has been applied (as described for the Recreational Wader scenario). The resulting preliminary groundwater cleanup levels for the protection of ecological receptors are presented in **Table 6**. The point of compliance would be groundwater at the shoreline/property boundary.

#### *3.4.2.2 Pore Water*

To determine groundwater cleanup levels that are protective of ecological receptors with respect to pore water, pore water attenuation factors have been considered. There is limited pore water data around the entirety of the site perimeter. However, based on discussions with EPA, use of empirical data is preferred over any modeling approach. Therefore, data from several coves of the CPA have been considered: Cell 2 (located along the southern portion of the inlet associated with the Graving Dock, also has a seawall), Cell 3 (located along the northern portion of a cove along the western shore of the CPA), and Cell 5 (located along the western portion of the Turning Basin). For each cell and the overall CPA, geometric means were calculated for shallow pore water samples and for shoreline monitoring well locations based on benzene and naphthalene concentrations (refer to **Appendix C**). Based on the calculated geometric means, groundwater to shallow pore water attenuation factors were calculated (refer to **Appendix C**). ARM has selected the shallow pore water attenuation factor of **75** for use in this Site Wide CMS, which was the factor from Cell 5 for naphthalene. This factor was selected for several reasons: 1) the Turning Basin would have less mixing than other areas surrounding the entire Sparrows Point peninsula, while also being more representative than Cell 2 which has a seawall; 2) Cell 5 included 7 ~~surface~~ pore water samples; 3) the Cell 5 factor was the lowest factor calculated based on the CPA data, and therefore will be conservative for use Site-Wide.

The shallow pore water attenuation factor of **75** will be used site-wide, and applied to the ~~surface~~ pore water screening levels for Ecological Receptors to obtain preliminary groundwater cleanup levels for the protection of the Ecological Receptors based on shallow pore water.

#### *3.4.2.3 Combined*

To determine groundwater cleanup levels that are protective of ecological receptors with respect to surface water, a surface water mixing / attenuation factor of 121 was applied to the surface water screening levels. In addition, the shallow pore water attenuation factor of 75 was applied to the pore water screening levels. The lowest of the two calculated screening levels was selected as the preliminary groundwater cleanup levels for the protection of ecological receptors. These cleanup levels are presented in Table 2 and Table 6. The point of compliance would be groundwater at the shoreline/property boundary.

### 3.4.3 **Resource Restoration**

USEPA expects corrective actions / final remedies to return usable groundwater to its maximum beneficial use, where practicable, within a timeframe that is reasonable. As previously discussed, USEPA has concluded that the maximum beneficial use of groundwater at Sparrows Point is industrial, commercial, or dewatering and that groundwater cleanup levels should be developed based on State surface water quality criteria.

Preliminary groundwater cleanup levels were developed to be protective of an Industrial Non-Potable Water User ~~(Composite Worker)~~. The Industrial Non-Potable Water User is intended to be a worst-case scenario receptor and assumes groundwater exposure during truck washing or similar. For this scenario, a groundwater extraction rate of 5 ~~gpm~~ gallons per minute has been assumed.

The COPC list identified in Section 3.2 includes multiple cancer and non-cancer COPCs. In order to account for cumulative risks, a target cancer risk of 1E-06 was utilized in the below equations to ensure that cumulative carcinogenic risk for groundwater remains below acceptable risk levels. For non-cancer COPCs, they were separated by target organ. The target non-cancer HQ (1.0) was divided by the number of COPCs contributing to that target organ HQ, in order to obtain a target HQ per target organ per COPC. This target HQ (per target organ per COPC) was used in the below equations to calculate preliminary groundwater cleanup levels for on-site composite workers to ensure that cumulative non-cancer risk by target organ remain below acceptable risk levels. Refer to Appendix D for preliminary groundwater cleanup level calculations.

Dermal Contact

Dermal exposures were assessed using the same equations as for the On-Site Utility Worker (refer to Section 3.4.1.2) and are based on the EPA RSL equations for resident / dermal contact with groundwater / tapwater. These equations have been conservatively used to calculate the Industrial Non-Potable Water User~~Composite Worker~~ dermal contact RBSL as follows:

$$RBSL_{inorg\_derm\_\cancel{cw}rr}\left[\frac{\mu g}{L}\right] = \frac{DA_{event\_\cancel{cw}rr} x\ 1{,}000\ cm^3/L}{K_p\ x\ ET_{\cancel{cw}rr}}$$



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For organic COPCs for which exposure time ($ET_{\cancel{cw}rr}$) is less than or equal to the chemical-specific time to reach steady state ($t^*$), the Industrial Non-Potable Water User ~~Composite Worker~~ dermal contact RBSL ($RBSL_{org\_derm\_\cancel{cw}rr}$) is calculated as:

$$RBSL_{org\_derm\_\cancel{cw}rr}\left[\frac{\mu g}{L}\right] = \frac{DA_{event_{uwrr}} x\ 1{,}000\,\frac{cm^3}{L}}{2\ x\ FA\ x\ K_p\ x\ \sqrt{\frac{6\ x\ \tau_{event} x\ ET_{\cancel{cw}rr}}{\pi}}}$$

For organic COPCs for which exposure time ($ET_{rec}$) is greater than the chemical- specific time to reach steady state ($t^*_{rec}$), the Industrial Non-Potable Water User ~~Composite Worker~~ dermal contact RBSL ($RBSL_{org\_derm\_\cancel{cw}rr}$) is calculated as:

$$RBSL_{org\_derm\_\cancel{cw}rr}\left[\frac{\mu g}{L}\right] = \frac{DA_{event\_\cancel{cw}rr}\ x\ 1{,}000\,\frac{cm^3}{L}}{FA\ x\ K_p\ x\left[\frac{ET_{uw}}{1+B} + 2\ x\ \tau_{event_{rr}}\ x\left[\frac{1+3B+3B^2}{(1+B)^2}\right]\right]}$$

Where:

$DA_{event\_\cancel{cw}rr}$ = Absorbed dose per event for Industrial Non-Potable Water User ~~Composite Workers~~ ($\mu g/cm^2$-event). Calculated.

$K_p$ = Dermal permeability coefficient of COPC in water (cm/hour). Chemical specific, refer to **Table 4**.

$\tau_{event}$ = lag time per event (hour/event). Chemical specific, refer to **Table 4**.

$t^*$ = time to reach steady state (hours). Chemical specific, refer to **Table 4**.

FA = fraction absorbed from water (unitless). Chemical specific, refer to **Table 4**.

$ET_{\cancel{cw}rr}$ = exposure time (hours/event), 8 hrs/event. Refer to **Table 3**.

B = ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless). Chemical specific, refer to **Table 4**.

The absorbed dose per event ($DA_{event\_\cancel{cw}rr(c)}$) for carcinogenic effects for all COPCs is calculated as:

$$DA_{event\_\cancel{cw}rr(c)}\left[\frac{\mu g}{cm^2 - event}\right] = \frac{TR\ x\ AT_c\ x\ LT\ x\ BW_{\cancel{cw}rr}\ x\ GIABS\ x\ 1000\ \mu g/mg}{ED_{\cancel{cw}rr}\ x\ EF_{\cancel{cw}rr}\ x\ SA_{\cancel{cw}rr}\ x\ SF_o}$$

and $DA_{event\_\cancel{cw}rr(nc)}$ for non- carcinogenic effects of all COPC types is calculated as:

$$DA_{event\_\cancel{cwrr}(nc)}\left[\frac{\mu g}{cm^2-event}\right] = \frac{THQ\ x\ AT_{nc,\cancel{cwrr}} x ED_{\cancel{cwrr}} x BW_{\cancel{cwrr}} x RfD x GIABS x 1000\ \mu g/mg}{ED_{\cancel{cwrr}}\ x\ EF_{\cancel{cwrr}}\ x\ SA_{\cancel{cwrr}}}$$

Where:
TR = Target Risk (unitless). Refer to **Table 3**.
THQ = Target Hazard Quotient (unitless) per COPC per target organ. Refer to **Appendix D**.
$AT_c$ = averaging time for carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
$AT_{nc,\cancel{cwrr}}$ = averaging time for non- carcinogens (days/yr), 365 days/yr. Refer to **Table 3**.
LT = lifetime (yrs), 70 yrs. Refer to **Table 3**.
$BW_{\cancel{cwrr}}$ = body weight (kg), 80 kg. Refer to **Table 3**.
$SA_{\cancel{cwrr}}$ = exposed body surface area ($cm^2$), 3,527 $cm^2$. Refer to **Table 3**.
$EF_{\cancel{cwrr}}$ = exposure frequency (events/year). Refer to **Table 3**.
$ED_{\cancel{cwrr}}$ = exposure duration (years). Refer to **Table 3**.
GIABS = gastrointestinal absorption fraction (unitless). Chemical specific, refer to **Table 4**.
$SF_o$ = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$. Chemical specific, refer to **Table 4**.
RfD = reference dose (mg/kg-day). Chemical specific, refer to **Table 4**.

Vapor Inhalation

Before calculating vapor inhalation risks to the Industrial Non-Potable Water User~~Composite Worker~~, each COPC must first meet the criteria for volatility where the Henry's Law Constant must be greater than $1 \times 10^{-5}$ atm-m³/mol. If it does not, then the chemical is not volatile enough to be assessed for vapor inhalation risks.

In order to calculate the vapor inhalation risks for the Industrial Non-Potable Water User ~~Composite Worker~~ scenario, the EPA RSL equation for composite worker air was utilized to calculate an outdoor air concentration. Then, a simplification of the ASTM E1739-95 Risk Based Corrective Action box model (Worksheet 3.3) was utilized with the conservative assumption of 100% volatilization. The result is a simple mass balance of total contaminant mass coming into the box with the groundwater (mass flux of contaminant in the groundwater in µg per minute) being mixed into the volume of clean air passing through the exposure area from upwind (cubic meters per minute) to give air concentration in the box in µg/cubic meter. For this scenario, the calculated acceptable outdoor air screening level concentration is converted to an applicable groundwater cleanup level.

First, the EPA RSL equation for composite worker air was utilized to calculate an outdoor air concentration for carcinogenic effects:

$$SL_{\cancel{ewrr}-air(c)}\left[\frac{\mu g}{m^3}\right] = \frac{TR\ x\ AT_c\ x\ LT}{ED_{\cancel{ewrr}}\ x\ EF_{\cancel{ewrr}}\ x\ ET_{\cancel{ewrr}}\ x\ \frac{1\ day}{24\ hrs}\ x\ IUR}$$

and for non- carcinogenic effects:

$$SL_{\cancel{ewrr}-air(nc)}\left[\frac{\mu g}{m^3}\right] = \frac{THQ\ x\ AT_{nc}\ x\ ED_{\cancel{ewrr}}\ x\ RfC\ x\ 1000\ \mu g/mg}{EF_{\cancel{ewrr}}\ x\ ED_{\cancel{ewrr}}\ x\ ET_{\cancel{ewrr}}\ x\frac{1\ day}{24\ hrs}}$$

Where:
TR = Target Risk (unitless). Refer to **Table 3**.
THQ = Target Hazard Quotient (unitless) per COPC per target organ. Refer to **Appendix D**.
$AT_c$ = averaging time for carcinogens (days/yr). Refer to **Table 3**.
LT = lifetime (yrs). Refer to **Table 3**.
$AT_{nc}$ = averaging time for non- carcinogens (days/yr). Refer to **Table 3**.
$EF_{\cancel{ewrr}}$ = exposure frequency (days/year). Refer to **Table 3**.
$ED_{\cancel{ewrr}}$ = exposure duration (years). Refer to **Table 3**.
$ET_{\cancel{ewrr}}$ = exposure time (hours/day). Refer to **Table 3**.
IUR = inhalation unit risk $(\mu g/m^3)^{-1}$. Chemical specific, refer to **Table 4**.
RfC = reference concentration ($mg/m^3$). Chemical specific, refer to **Table 4**.

Then, the calculated outdoor air concentration is converted to an applicable groundwater cleanup level:

$$RBSL_{\cancel{ewrr}-gw}\left[\frac{\mu g}{L}\right] = \frac{SL_{\cancel{ewrr}-air}\ x\ U_{air}\ x\ \delta_{air}\ x\ W}{Q_{GW}}$$

Where:
~~H' = Henry's Law constant for the contaminant of concern (unitless). Chemical specific, refer to **Table 4**.~~
$U_{air}$ = wind speed (m/s). Assumption of 4.69 m/s, refer to **Table 3**.
$\delta_{air}$ = ambient air mixing zone height (m). Assumption of 2 ~~c~~m, refer to **Table 3**.
W = ~~dimension of soil source~~work area width ~~parallel~~ perpendicular to wind direction (m). Assumption of 6.096m (20 ft), ~~R~~refer to **Table 3**.
$Q_{GW}$ = groundwater extraction rate (L/s). Assumption of 0.31542 L/s (5 gallons per minute), r~~R~~efer to **Table 3**.

Combined Exposure Routes

For volatile COPCs, combined dermal and inhalation RBSLs are calculated. For carcinogenic effects, the Industrial Non-Potable Water User ~~Composite Worker~~ RBSLs ($RBSL_{comb\_\cancel{cw}rr(c)}$) are calculated as:

$$RBSL_{comb\_\cancel{cw}rr(c)}\left[\frac{\mu g}{L}\right] = \frac{1}{\frac{1}{RBSL_{org\_derm(c)}} + \frac{1}{RBSL_{dir\_inhal\_\cancel{cw}rr(c)}}}$$

For non- carcinogenic effects, the Industrial Non-Potable Water User ~~Composite Worker~~ RBSLs ($RBSL_{comb\_\cancel{cw}rr(nc)}$) are calculated as:

$$RBSL_{comb\_\cancel{cw}rr(nc)}\left[\frac{\mu g}{L}\right] = \frac{1}{\frac{1}{RBSL_{org\_derm(c)}} + \frac{1}{RBSL_{dir\_inhal\_\cancel{cw}rr(nc)}}}$$

The lowest of the carcinogenic and non-carcinogenic combined direct contact screening levels was selected as the RBSLs for the Resource Restoration / Industrial Non-Potable Water User ~~Composite Worker~~ scenario, and are presented in **Table 7**. The point of compliance for these cleanup levels would be Site-wide.

In addition, preliminary groundwater cleanup levels were calculated based on protection of ecological receptors from a potential groundwater discharge after extraction / use (as a point source discharge). Surface water screening levels for marine or saltwater aquatic life, and for chronic exposure, were selected. To determine groundwater cleanup levels that are protective of ecological receptors, a point source discharge mixing factor was applied to the surface water screening levels.

According to Code of Maryland Regulations (COMAR) ~~26.08.01.01 *et seq.*~~ 26.08.02.05 D *et seq.* calculations may be used to establish mixing zones for the Application of Toxic Substance Chronic Criteria for the Protection of Aquatic Life. In particular, the flows used for freshwater streams and rivers should be the 30Q5 values (26.08.02.05 D.(2)(a)), and the flows for estuaries and open ocean can be determined in several ways, including "Specific data, when available, for the mean water level and average tidal velocity and, when appropriate, the 30Q5 stream flow" (26.08.02.05 D.(2)(b)(i)). ~~shall be the 30Q5 value for freshwater streams and rivers.~~

30Q5 flows were not available for the subject site. Nearby USGS gauging stations with similar watershed areas were used to estimate a 30Q5 flow for the Site based on a ratio of drainage areas (refer to Appendix C). Then, a mixing factor was calculated based on the 30Q5 flow for the Site and an assumed groundwater point source discharge of 5 gallons per minute from a hose or similar. Based on this, a mixing factor of 28 was calculated for the Old Road Bay / Jones Creek portion of the Site, and a mixing factor of 157 was calculated for the Bear Creek portion of the Site. To be conservative, the point source discharge mixing factor of **28** will be utilized for this scenario.

These human-health related preliminary groundwater cleanup levels (Industrial Non-Potable Water User ~~Composite Worker~~ scenario) were utilized along with the preliminary groundwater cleanup levels for the protection of ecological receptors (including the point source discharge mixing factor of **28**). The Resource Restoration preliminary groundwater cleanup levels will be used to determine where resource protection may be required in order to return sitewide groundwater to its maximum beneficial use. These screening levels were compared to all site-wide groundwater results.

The Resource Restoration preliminary groundwater cleanup levels are presented in **Table 2 and Table 7**.

# 4.0 NATURE AND EXTENT OF GROUNDWATER IMPACTS

This Site-Wide Groundwater CMS excludes the CPA (which includes the Coke Point Landfill and the Coke Oven Area, and encompassing Parcels B10, B11, ~~and~~ B12, and B18) and the RWM (Parcel A3); these areas will be addressed under separate CMS Reports.

Based on the selected Media Cleanup Levels (all presented in **Table 2**) and Points of Compliance, groundwater results were screened against COPCs (as identified in **Section 3.2**) as follows:

- On-Site Industrial Worker: COPCs in shallow groundwater across the TPA Property were compared to the VISLs.
- On-Site Utility Worker: COPCs in shallow groundwater across the TPA Property were compared to the calculated preliminary groundwater cleanup levels.
- Off-Site Recreational Wader: COPCs in shallow and intermediate groundwater from shoreline locations were compared to the calculated preliminary groundwater cleanup levels.
- Off-Site Recreational User (Fish and Crab Ingestion): COPCs in shallow and intermediate groundwater from shoreline locations were compared to the calculated preliminary groundwater cleanup levels.
- Ecological Receptors: COPCs in shallow and intermediate groundwater from shoreline locations were compared to the calculated preliminary groundwater cleanup levels.
- Resource Restoration: COPCs in shallow and intermediate groundwater across the TPA Property were compared to the calculated preliminary groundwater cleanup levels.

**Figure 14** presents the site-wide groundwater monitoring network utilized for comparison of preliminary groundwater cleanup levels to groundwater across the TPA Property. **Figure 15** presents the shoreline groundwater monitoring network utilized for comparison of preliminary groundwater cleanup levels to groundwater from shoreline locations only. For locations with NAPL in wells or piezometers (refer to **Figure 16**) it is assumed that NAPL presents a potential risk to the above listed receptors.

**Figures 17-21** conservatively, and for information use only, present a point-by-point comparison of the groundwater cleanup levels to discrete groundwater locations / concentrations. However, the groundwater cleanup levels should be compared to the ~~average~~ representative groundwater concentrations ~~in~~ for an area, given that a receptor's exposure encompasses a larger habitat or area.[1]

### 4.1 On-Site Industrial Worker

**Figure 17** presents site-wide locations with groundwater exceedances for the On-Site Industrial Worker scenario. There were multiple locations with exceedances for one or more of the following constituents: five VOCs (1,1-DCA, 1,1-DCE, benzene, tetrachloroethene, and trichloroethene) and one SVOC (naphthalene).

### 4.2 On-Site Utility Worker

**Figure 18** presents site-wide locations with groundwater exceedances for the On-Site Utility Worker scenario.

### 4.3 Off-Site Recreational Wader

**Figure 19** presents shoreline groundwater sampling locations with groundwater exceedances for the Off-Site Recreational Wader scenarios. There were several locations with exceedances for hexavalent chromium and iron. However, hexavalent chromium was flagged as an exceedance based on elevated detection limits in several non-detect samples. The maximum detected concentration for hexavalent chromium was below the Off-Site Recreational Wader groundwater cleanup levels; therefore, hexavalent chromium is eliminated as a COC. For iron exceedances,

ARM compared the geometric mean for iron results in monitoring wells along the southeast shoreline (where recreational wading is expected to occur) to the calculated groundwater cleanup levels for Off-Site Recreational Wader (refer to **Table 8**, and to **Appendix F** for the utilized dataset based on southeastern shoreline groundwater data). For non-detect results, one half of the detection limit was used for calculation purposes. If both total and dissolved metals results were available for a sample location, then only the dissolved metals result was utilized for calculation purposes. The geometric mean for iron was below calculated groundwater cleanup levels for Off-Site Recreational User. It also should be noted that iron is slag-related and is considered anthropogenic background and unrelated to releases from RCRA regulated units or SWMUs.

[1] The point-by-point comparison is not appropriate for evaluations of potential exposure point concentrations within possible exposure areas or for establishing clean-up or remediation goals, because it is not representative of potential risk or ecological conditions that are expected to be encountered. It is offered solely as information to be considered in determining whether additional evaluations are recommended.

Based on the analysis, both hexavalent chromium and iron were eliminated as COCs for the recreation wader scenario, and perimeter groundwater does not present a risk to Off-Site Recreational Waders.

~~For comparison of COPCs in shoreline groundwater sampling locations to the Off-Site Recreational Wader scenario, there were no exceedances for dissolved phase concentrations. Therefore, no figure showing exceedances of Off-Site Recreational Wader preliminary groundwater cleanup levels is provided. The only potential for a risk to Off-Site Recreational Waders is from NAPL detected in shoreline monitoring wells on Parcel B18.~~

### 4.4 Off-Site Recreational User

**Figure 20~~19~~** presents shoreline groundwater sampling locations with groundwater exceedances for the Off-Site Recreational User scenario. There were several locations with exceedances for one or more of the following: hexavalent chromium, manganese, PCBs, and naphthalene. However, a point-by-point comparison is not representative for this off-site recreational user scenario (via ingestion of fish and crabs) over an exposure duration of 26 years.

Therefore, ARM compared the geometric mean for COPCs with exceedances in monitoring wells along the entire site-wide shoreline to the calculated groundwater cleanup levels for Off-Site Recreational User (refer to **Table 9~~8~~**, and to **Appendix F** for the utilized dataset based on site wide shoreline groundwater data). For non-detect results, one half of the detection limit was used for calculation purposes. If both total and dissolved metals results were available for a sample location, then only the dissolved metals result was utilized for calculation purposes. For hexavalent chromium, manganese, and naphthalene, exceedances were not widespread, with exceedance frequencies of 3.4~~1~~%, 6.3%, and ~~5~~2.7%, respectively. For PCBs, while there were multiple exceedances, the maximum concentration was less than two times the calculated screening level. The geometric mean for all ~~three~~ four COPCs were below calculated groundwater cleanup levels for Off-Site Recreational User and all four were, therefore, eliminated as COCs.

Based on the low detection frequency, limited areas of elevated concentrations, and a comparison of the geometric mean concentrations in monitoring wells along the site-wide shoreline to the calculated groundwater cleanup levels for Off-Site Recreational User, perimeter groundwater does not present a risk to Off-Site Recreational User via fish and crab ingestion.

### 4.5 Ecological Receptors

**Figure ~~19~~ 21** presents side-wide locations with groundwater exceedances for Ecological Receptors based on protection of pore water (this is more conservative and is therefore also protection of surface water). There were multiple locations with exceedances for one or more of the following constituents: ~~one SVOC (2-Methylnaphthalene), seven~~ four inorganic constituents (~~aluminum,~~

hexavalent chromium, cobalt, iron, and manganese~~and nickel~~). However, hexavalent chromium was flagged as an exceedance based on elevated detection limits in several non-detect samples. The maximum detected concentration for hexavalent chromium was below the Ecological Receptor groundwater cleanup levels; therefore hexavalent chromium is eliminated as a COPC. For iron and manganese, they are both slag-related and considered anthropogenic background and unrelated to releases from RCRA regulated units or SWMUs. In ~~However, a~~addition, a point-by-point comparison is not representative of potential risk or ecological conditions that are expected to be encountered based on the entire habitat of a given receptor.

Therefore, ARM compared the geometric mean for COPCs with exceedances in monitoring wells along the entire site-wide shoreline to the calculated groundwater cleanup levels for Ecological Receptors based on protection of pore water (refer to **Table** 10~~9~~, and to **Appendix F** for the utilized dataset based on site wide shoreline groundwater data). For non-detect results, one half of the detection limit was used for calculation purposes. If both total and dissolved metals results were available for a sample location, then only the dissolved metals result was utilized for calculation purposes. For cobalt and manganese, exceedances were not widespread, with exceedance frequencies of 6.3% and 1.6%, respectively. For iron, while there were multiple exceedances, iron is related to anthropogenic background conditions. ~~Exceedances were not widespread, with exceedance frequencies of below 5% for all COPCs except cobalt, which had an exceedance frequency of 13.3%.~~ The geometric mean for all ~~four~~ three COPCs were below calculated groundwater cleanup levels for Ecological Receptors based on protection of pore water and were, therefore, eliminated as COCs.

Based on the low detection frequency, limited areas of elevated concentrations, and a comparison of the geometric mean concentrations in monitoring wells along the site-wide shoreline to the calculated groundwater cleanup levels for Ecological Receptors, perimeter groundwater does not present a risk to ecological receptors (and the benthic community as a whole). The cleanup levels utilized were based on pore water, and are also protective of surface water.

### 4.6 Resource Restoration

**Figure** ~~20~~ 22 presents site-wide locations with groundwater exceedances for Resource Restoration. As discussed in Section 3.4.3, the human-health related preliminary groundwater cleanup levels were selected for the interior of the site, while the ecological screening levels were selected for the perimeter monitoring wells.

As discussed in Section 4.4 and presented in **Table** 10~~9~~, perimeter groundwater does not present a risk to ecological receptors (and the benthic community as a whole).

For the human-health related preliminary groundwater cleanup levels, there were multiple locations with exceedances for one or more of the following constituents: ~~seven~~ eight VOCs (1,1-

Dichloroethane, 1,2,4-Trimethylbenzene, benzene, cis-1,2-Dichloroethene, tetrachloroethene, toluene, trichloroethene, and vinyl chloride~~, and 1,4-Dioxane~~), ~~eleven~~ thirteen SVOCs (1,1-Biphenyl, 2,4-Dimethylphenol, 2-Methylnaphthalene, benz[a]anthracene, benzo[a]pyrene, benzo(b)fluoranthene, benzo[k]fluoranthene, chrysene, fluoranthene, ~~dibenzo(a,h)anthracene,~~ indeno(1,2,3-c,d)pyrene, naphthalene, ~~and~~ pentachlorophenol, and pyrene), ~~three~~ nine inorganic constituents (arsenic, beryllium, cadmium, hexavalent chromium, cobalt, iron, manganese, thallium, and vanadium), and PCBs.

**Table** ~~10~~ 11 presents a summary of groundwater COPC exceedances by Receptor / Pathway.

### 4.7 Interim Measures

To date, there have been multiple Interim Measures focused on removal of NAPL and NAPL impacted soil that is impacting groundwater. While **Figures 14-18** may indicate NAPL or dissolved phase exceedances in these locations, this is based on pre – excavation results. In each case as itemized below, NAPL/soil removal was implemented and approved by MDE. The IM locations are shown on **Figure 16**.

- Parcel A10 (Former underground storage tank [UST]): In January and February 2020, two USTs were removed, as well as approximately 350 tons of NAPL impacted soil, and concrete subgrade structure / rubble. No subsequent NAPL gauging or groundwater sampling has been conducted at Parcel A10 since the UST and soil removal.

- Parcel B5 (Former AST, NW Corner of Parcel B5): In April and May 2019, approximately 5,700 cubic yards (CY) of NAPL impacted soil was removed. In addition, approximately 139,000 gallons of groundwater was removed (during dewatering) and transported to the Water Treatment Plant. No subsequent NAPL gauging or groundwater sampling has been conducted since the soil removal.

- Parcel B6 (Former No. 6 Oil Pump House): In June 2017, approximately 3,800 CY of NAPL impacted soil was removed. No subsequent NAPL gauging or groundwater sampling has been conducted since the soil removal.

- Parcel B22 (Hot Strip Mill Drum Handling Area): In June 2017, approximately 1,300 CY of NAPL impacted soil was removed. No subsequent NAPL gauging or groundwater sampling has been conducted since the soil removal.

- Parcel B22 (PORI Lagoon): In December 2020, approximately 800 CY of sediment was removed from the lagoon.

In addition to the above corrective actions, NAPL gauging and bailing (when required) is ongoing at several Parcels:

- Parcel A8 (A8-017-PZ vicinity): NAPL gauging is ongoing. Measurable NAPL requiring bailing has not been identified.
- Parcel B6 (Historic Waste Oil Pit): NAPL was identified and delineated. 11 perimeter piezometers ~~are~~ were gauged on a quarterly basis no ensure no NAPL migration. No active bailing or other IMs. All piezometers were abandoned in May 2021 (following MDE approval) due to the lack on NAPL detections. Test pits were advanced in July 2021 to evaluate NAPL thickness and potential mobility; this will be discussed further in subsequent sections.
- B8 (East of Former Billet Building): Monthly gauging and NAPL removal in 3 MWs; 4.6~~0~~ gallons NAPL removed thru ~~December 2020~~June 2021. In addition, monthly vacuum events were completed at B8-002-MWS from May to July 2021.

# 5.0 REFERENCES

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